Per (sec. 15)

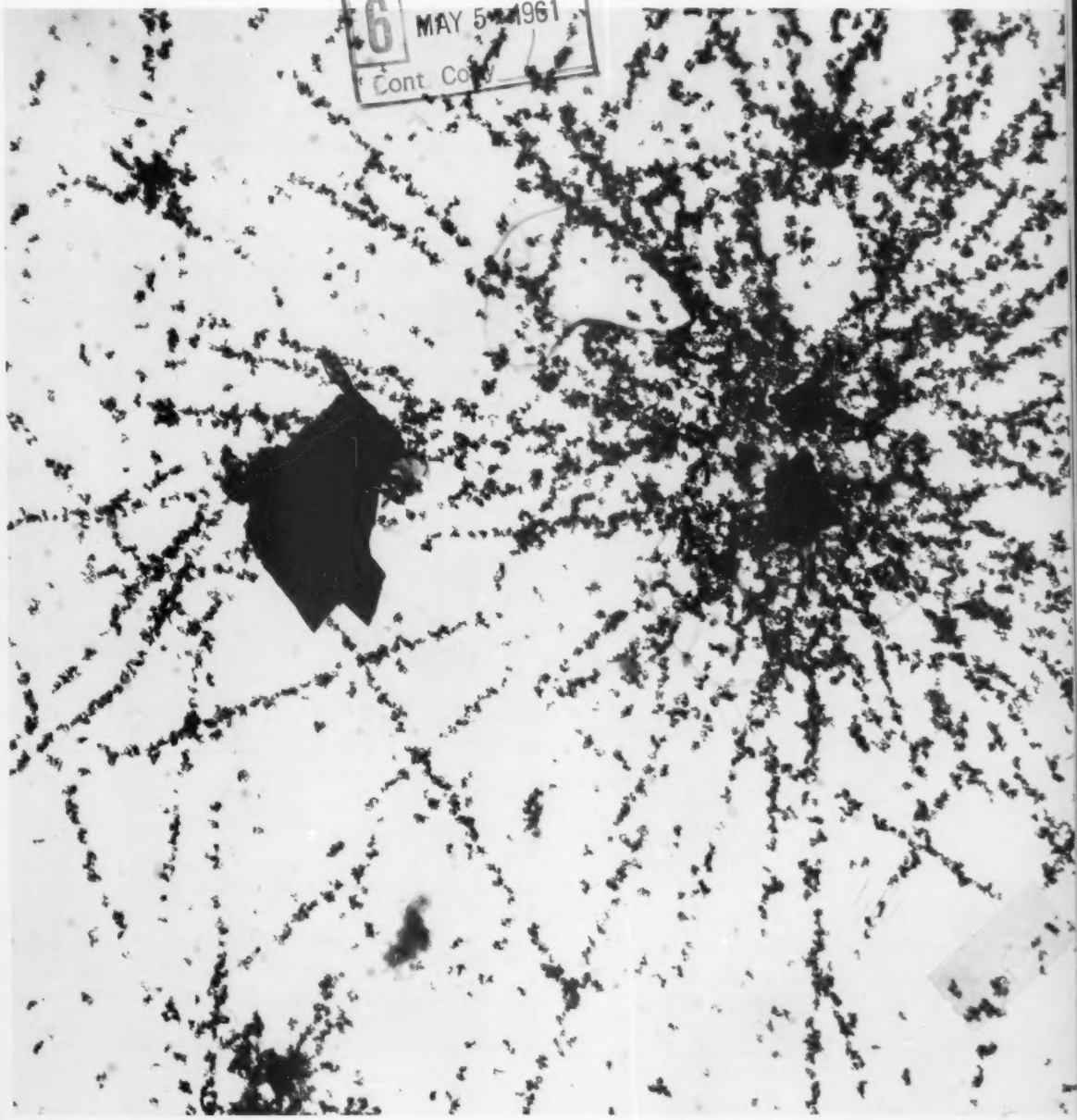
SCIENCE

5 May 1961

Vol. 133, No. 3462

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

6 MAY 5 1961
Cont. Copy



LEITZ EXCLUSIVE: *the only quality microscope that combines these important features...*

BINOCULAR MEDICAL AND LABORATORY MICROSCOPE SM. Equipped with inclined binocular body; mechanical stage; two-lens condenser with swing-out upper element and iris diaphragm; quadruple nosepiece; mirror and fork. Optical outfit with achromats 3.5x, 10x, and 45x and 100x oil immersion with spring-loaded mounts plus 10x eyepieces.

MONOCULAR MEDICAL AND LABORATORY MICROSCOPE SM. Same as above, but equipped with inclined monocular tube. If desired, monocular microscope can be converted to a binocular unit in a simple one-step operation.

LEITZ TECHNICAL SERVICE is unique in the United States, providing one of the most extensive service and repair facilities in the field of scientific instruments.

1. ***Single-knob focusing*** combines coarse and fine focusing for faster, more convenient operation...saves time... simplifies your microscope studies...lets you work in greater comfort and ease.
2. ***The world's finest optics***...high precision construction ...the most exacting operation – all in a moderately priced instrument.
3. ***Accepts all standard slide sizes.*** Mechanical stage accepts both 3" x 1" and 3" x 2" slides.
4. ***Retractable spring-load mounts*** on high-powered objectives provide positive protection against damage to slide or front lens.
5. ***Anti-reflection coating*** on tubes and optics throughout.
6. ***Extra-wide objective magnification range 45-1250x.***
7. ***Monocular or binocular body rotatable 360°*** with one-step locking at any point.
8. ***Variety of mechanical stages*** available.
9. ***Selection of attachable illuminators,*** interchangeable with mirror.
10. ***Wide-field or high-eyepoint eyepieces*** (for wearers of glasses) available at slight extra cost.
11. ***Contour-fitted carrying case*** protects microscope.

GET ALL THE FACTS...WRITE FOR LITERATURE... for full information on all the important new features and conveniences built into the latest SM microscope.

FILL OUT COUPON...MAIL TODAY!

E. LEITZ, INC. Dept: SC-55
468 Park Avenue South, New York 16, New York
Gentlemen: Please send me complete information on the:
☐ Model SM microscope.
☐ Kindly have representative ☐ phone or ☐ write me for appointment to demonstrate SM microscope at no obligation to me.

Name_____
Address_____
City_____ Zone_____ State_____
Telephone_____

37761

Leitz

E. LEITZ, INC., 468 PARK AVENUE SOUTH, NEW YORK 16, N. Y.
Distributors of the world-famous products of Ernst Leitz G. m. b. H., Wetzlar, Germany—Ernst Leitz Canada Ltd.
LEICA CAMERAS · LENSES · PROJECTORS · MICROSCOPES · BINOCULARS

SAUNDERS science texts

Important Books to Fill Your Needs for Fall College Classes

— Balinsky —

AN INTRODUCTION TO EMBRYOLOGY

Sound guidance on otogenetic development

Here is an unusual text designed to provide students with a general understanding of the complicated processes of development. Dr. Balinsky presents embryology as a single science—logically integrating the traditional "descriptive" and the modern "experimental" approaches.

You'll find in this book a thorough introduction to the broad field of embryology, including gametogenesis—fertilization—cleavage—gastrulation—determination of the primary organ rudiments—embryonic adaptions—the genetic control of organogenesis—metamorphosis—asexual reproduction—development of the mesodermal organs in vertebrates—the genetic factors during gastrulation and formation of primary organ rudiments.

The author provides a solid background for the student, showing embroyonic development of vertebrates by processes and by development of organ systems. He cites and explains experimental evidence for the interpretation of developmental and growth processes, emphasizing the physiology of development.

This unique volume equips the student with the knowledge he needs to understand and critically evaluate further information on the science of embryology.

By B. I. BALINSKY, Dr. Biol. Sc., Professor of Zoology, University of the Witwatersrand, Johannesburg, South Africa. 562 pages, 6" x 9¼", 291 illustrations. $7.75.

— Newby —

A GUIDE TO THE STUDY OF DEVELOPMENT

A unique laboratory manual

Here is an ideal laboratory manual that serves as an excellent companion for the Balinsky book. It includes the directions for the microscopic examinations of the serial sections of progressive stages in the development of the chick and pig embryos. Unlike other manuals, it also includes extensive discussions on what causes the changes in the development of these two examples. These discussions cite experimental studies not covered in classroom laboratory work, shedding additional light on the nature and causes of development. They include: The Organization of the Egg; Formation of the Embryo; Development of the Organs; Interrelationships Between Developing Organs. The laboratory exercises themselves cover: Life Cycle of an Animal—Reproduction and Fertilization—Earliest Stages of Chick Development—The Young Embryo—Organ Primordia—Mammalian Development Including Early Stages and Formation—Etc.

Well organized, clearly written, and graphically illustrated, this unique manual gives the student a better understanding of embryological processes.

By WILLIAM W. NEWBY, Ph.D., Division of Biological Sciences, University of Utah. 217 pages, 8¼" x 11", illustrated. $4.00.

— Davenport —

HISTOLOGICAL AND HISTOCHEMICAL TECHNICS

A penetrating examination of methods

This concise, clearly-written text gives the student a thorough understanding of modern processing and examination of biological materials for microscopic study, including methods of preparing organs, tissues or tissue components of vertebrates, invertebrates, and plants.

Fundamental information is provided on the nature of tissues, the technics of fixation, washing, dehydrating, clearing, embedding, sectioning, mounting, and staining. Staining methods, staining solutions and fixing fluids are fully presented.

The section of histochemistry gives a brief and up-to-date survey of representative histochemical procedures. Technics to determine inorganic and organic constituents of tissues and enzymes are described. An entire chapter is devoted to applications of Schiff's Reagent.

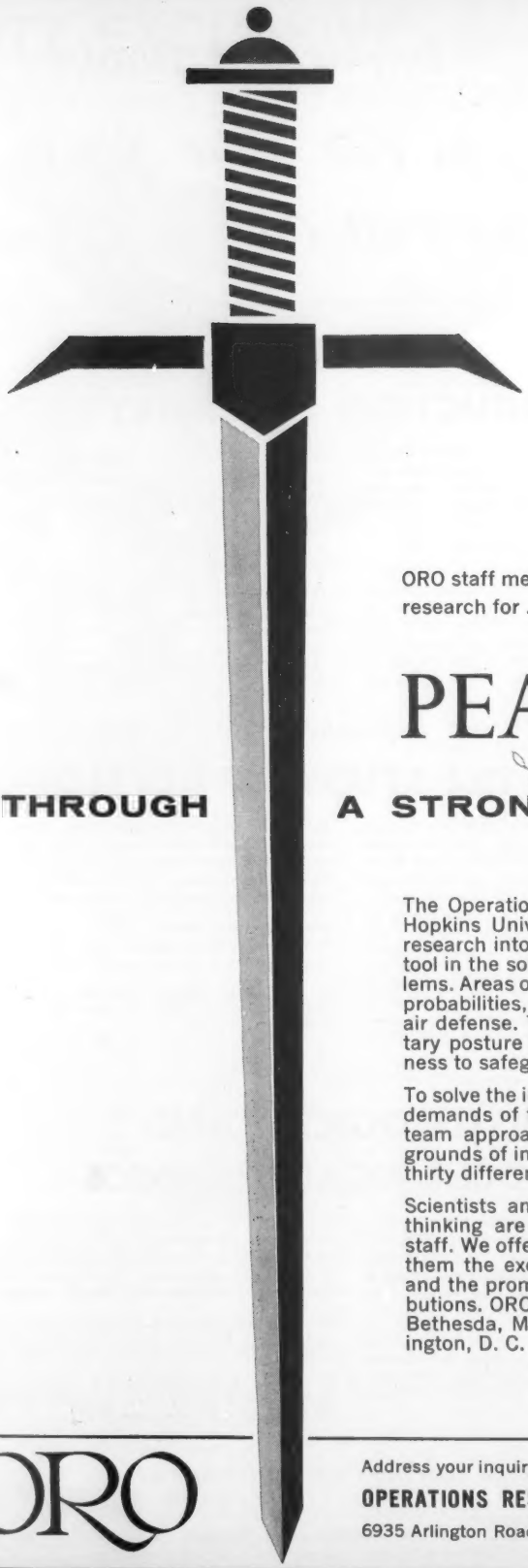
This book logically covers not only the technical methods of histology, but also presents the reasons behind the methods.

By HAROLD A. DAVENPORT, M.D., Professor of Anatomy, Northwestern University Medical School, Chicago, Illinois. 401 pages, 6" x 9", illustrated. $7.00.

Gladly sent to college teachers on approval

W. B. SAUNDERS COMPANY **West Washington Square • Philadelphia 5**

SCIENCE is published weekly by the AAAS, 1515 Massachusetts Ave., NW, Washington 5, D.C. Second-class postage paid at Washington, D.C., and additional mailing office. Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢.



ORO staff members pioneer operations research for . . .

PEACE

THROUGH A STRONG DEFENSE

The Operations Research Office of the Johns Hopkins University has pioneered operations research into a powerful and flexible scientific tool in the solution of world-wide military problems. Areas of application include strategy, war probabilities, tactics, logistics, intelligence, and air defense. The result: a strong national military posture with improved operational readiness to safeguard the peace.

To solve the intricate problems posed by future demands of the Army, ORO employs a mixed-team approach combining the diverse backgrounds of individuals representing more than thirty different disciplines.

Scientists and engineers capable of creative thinking are invited to join our professional staff. We offer you assignments that carry with them the excitement of a pioneering venture and the promise of significant scientific contributions. ORO's modern facilities are located in Bethesda, Md., a residential suburb of Washington, D. C.

ORO

Address your inquiry to: John C. Burke, Research Personnel Officer

OPERATIONS RESEARCH OFFICE / The Johns Hopkins University

6935 Arlington Road • Bethesda 14, Maryland

5 May 1961, Volume 133, Number 3462

SCIENCE

Editorial

How Helpful Is Freedom? 1393

Articles

Information Theory: *H. H. Goldstine* 1395

A brief survey is made of the recent developments and the current status of information theory.

Chromosome Cytology and Evolution in Primates: *E. H. Y. Chu* and *M. A Bender* 1399

Study of chromosomes adds to our knowledge of evolutionary relationships among primates.

Human Behavior during the Tsunami of May 1960: *R. Lachman, M. Tatsuoka, W. J. Bonk* 1405

Research on the Hawaiian disaster explores the consequences of an ambiguous warning system.

Science in the News

Science in the Courts: The Supreme Court Is Asked To Decide on the Inherent Dangers of Nuclear Reactors 1410

Book Reviews

The Atom Within Us and *The Coil of Life*, reviewed by *G. Hardin*; other reviews 1414

Reports

Afferent Units in Dorsal Roots of Cat Driven by Respiration: *A. A. Siebens* and *F. Puletti* 1418

Density of the Lunar Atmosphere: *E. J. Öpik* and *S. F. Singer* 1419

Rare Tumor in Coast Redwood, *Sequoia sempervirens: C. F. Emanuel* 1420

Alternation as Function of Preliminary Training and Type of Deprivation: *S. Hellyer* and *J. H. Straughan* 1422

Electron Microscopy and Autoradiography: *L. A. George II* 1423

Phototropic Inversion in Phycomyces: *E. S. Castle* 1424

Nitrogen Deficiency and Fluoride Susceptibility of Bean Seedlings: *D. F. Adams* and *C. W. Sulzbach* 1425

Spinal Reflexes and Seizure Patterns in the Two-Toed Sloth: *D. W. Esplin* and *D. M. Woodbury* 1426

Haptoglobin Types in Poland: *K. Murawski* and *T. Miszczak* 1427

Recovery from Electroconvulsive Shock as a Function of Infantile Stimulation: *R. W. Bell, G. Reisner, T. Linn* 1428

Association Affairs

The Third Denver Meeting: Some Background 1429

Departments

Forthcoming Events; New Products 1432

Cover

Radioactive and nonradioactive particles collected on a membrane filter used in sampling air for radioelements. The many alpha tracks observed as reduced silver grains emanating from the plutonium dioxide particles distinguished them from nonradioactive material. See page 1423 (electron microscope, × 8400). [L. A. George II, Hanford Laboratories, General Electric Co.]

FISHER STOCKS WHAT

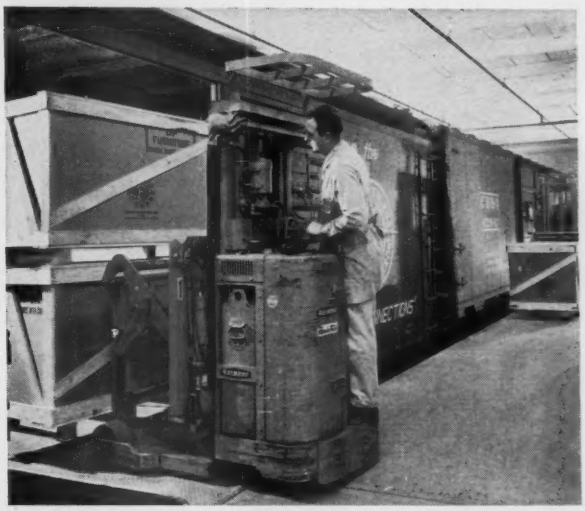
Depend on fast delivery from Fisher's 14 convenient branches. Newest is in Boston, boosting Fisher's total warehouse space to more than three-quarters of a million square feet. In each strategically located branch, skilled crews fill your order carefully, ship it promptly.

T YOU NEED!

WELL-STOCKED shelves at Fisher Scientific's new Boston branch (left) attest to the huge Fisher inventory: over 20,000 different instruments, appliances, glassware items and furniture units . . . over 7000 different chemicals. Each Fisher branch maintains its own comprehensive stocks so one order can bring your laboratory everything it requires . . . a **single source** that saves you time and money.

Comprehensive stocks are just one feature of the Fisher organization . . . others are noted below. In total, they are the reason Fisher Scientific is a leader in the field of laboratory instrumentation and reagent manufacture.

Reduce "housekeeping" time, costs. New Standard Washer gets glassware sparkling clean . . . quickly, economically, safely. It was developed for small labs by Fisher engineers who pioneered much of the apparatus you use.



Speed lab expansion, avoid delays. Order Fisher Unitized Furniture that's quickly available from stock. And take advantage of Fisher's many other services such as lab planning, free technical information, expert instrument repairs.

Get rigidly controlled purity in reagent-grade chemicals, "spectranalyzed" solvents from Fisher. In its modern plant, Fisher makes these and other high-purity chemicals under strict controls to assure uniform quality.

Want to have more facts about how Fisher can help you? Details in free, data-packed bulletins. Clip, fill out and mail coupon to Fisher Scientific Company, 139 Fisher Building, Pittsburgh 19, Pa.

Fisher Scientific Company
139 Fisher Building
Pittsburgh 19, Pa.

Please send me the following information:

- ☐ "This Is Fisher"
- ☐ Fisher Glassware Washers
- ☐ Fisher "Spectranalyzed" Solvents
- ☐ Fisher "Unitized" Furniture

Name_____ Title_____
Please Print

Company_____

Street_____

City_____ Zone_____ State_____

G-175

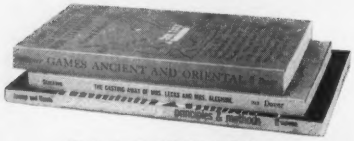
FISHER SCIENTIFIC

World's Largest Manufacturer-Distributor of Laboratory Appliances & Reagent Chemicals

Boston • Chicago • Fort Worth • Houston • New York • Odessa, Texas
Philadelphia • Pittsburgh • St. Louis • Washington • Montreal • Toronto

unusual values in hard-to-find books! many now printed in low-priced editions for the first time! only 75c to $2.95!

DOVER



Biological, Medical Science

CP614. Unabridged! CONDITIONED REFLEXES, I. Pavlov. Pavlov's own final presentation of 20 years experimentation on cerebral cortex and its functions. Classic of physiology, one of world's most influential books. Authorized Anrep translation. 445pp. Paperbd. $2.25

CP526. CULTURE METHODS FOR INVERTEBRATE ANIMALS, J. G. Needham, et al. Indispendable lab compendium of culture methods for invertebrates from protozoa to chordata. Hundreds of species in 33 classes covered in 313 articles. Describes food, environment, reproductive conditions, etc. 621pp. Paperbd. $2.75

CP632. THE LIFE OF PASTEUR, Rene Vallery-Radot. The definitive biography, by Pasteur's son-in-law, famed for detailed explanations of Pasteur's world-shaking discoveries in crystallography, fermentation, infectious wounds, contagious diseases, etc. Unavailable for years. 500pp. Paperbd. $2.00

CP598. HEREDITY AND YOUR LIFE, A. Winchester. Lively, thorough, non-technical coverage of genes, mutations, heredity, genius & idiocy, etc. 60 illus. 333pp. Paperbd. $1.45

CP206. BIOLOGY OF THE LABORATORY MOUSE, G. Snell, ed. Comprehensive lab manual prepared by staff of Roscoe B. Jackson Memorial Lab. Embryology, reproduction, histology, mutation, anatomy, diseases, cancer research, etc. 172 illus. 508pp. 6 x 9. Clothbd. $6.00

CP574-5. 3rd. revised edition! MATHEMATICAL BIOPHYSICS: Physico-Mathematical Foundations of Biology, N. Rashevsky. The greatest systematic application of math to biological processes. Authoritative presentation-introduction of one of most exciting areas of modern biophysics. 256 illus. 985pp. 2 vols. The set, paperbd. $5.00

Mathematics

CP747. First English translation! ELEMENTARY CONCEPTS OF TOPOLOGY, P. Alexandroff. For mathematicians who want a lucid, intuitive survey; students intending to continue; researchers in other fields. "A glowing example of the harmony between intuition and thought," David Hilbert, in his introduction. 73pp. $1.00

CP750-1. New! TEXT BOOK IN ALGEBRA, G. Chrystal. One of most famous texts ever written. Not survey, but exhaustive, complete coverage and background for topics of elementary algebra. Total of 113pp. 2 vols. The set, paperbd. $4.70

CP737. Just out! HIGHER GEOMETRY: An introduction to Advanced Methods in Analytic Geometry, F. Woods. Rigorous development of 1-, 2-, 3-, 4-, and n-dimensional coordinate systems. Highly respected. 423pp. Paperbd. $2.00

CP728. New! AN ELEMENTARY TREATISE ON ELLIPTIC FUNCTIONS, Arthur Cayley. Long out of print. Jacobi-Legendre theories. 398pp. Paperbd. $2.00

Applied Mathematics & Engineering

CP727. New! THEORY AND OPERATION OF THE SLIDE RULE, J. Ellis. Original Dover publication. Not skimpy manual, but extensive, thorough course developed at U. of Kansas. Fast methods, hundreds of short-cuts, full ground in theory, plenty of practice problems. Save hundreds of hours. 321pp. Paperbd. $1.50

CP193. HIGHER MATHEMATICS FOR STUDENTS OF CHEMISTRY & PHYSICS, H. Mellor. Diff & integ. calculus, infinite series, differential equations, etc., in terms of chemistry and physics subject matter. Invaluable desk companion, self-study text. 800 problems. 641pp. Paperbd. $2.00

CP734-5. Just off the presses! MATHEMATICS OF MODERN ENGINEERING, E. G. Keller, R. E. Doherty. Revolutionary working text, reference, developed by world-famous mathematician-aerodynamicist for G. E.'s famous advanced engineering course. Determinants, tensors, Heaviside operational calculus, other higher math topics presented in way that engineer or researcher can use them to set up, analyze, and solve actual problems of modern technology: linear and non-lineag networks, rotating machinery, electrical systems, aerodynamic and missile motion, vibration, etc. Based on full, recognition that technical researcher's and mathematician's needs differ considerably. Internationally used and acclaimed. Total of 633pp. 2 vols. The set, paperbd. $3.30

CP755. New! STRENGTH OF MATERIALS, J. P. Den Hartog. Developed to meet needs of M.I.T. students. Principles, plus considerable emphasis on practical methods, hundreds of problems. 331pp. Paperbd. $1.95

CP726. APPLIED ELASTICITY, J. Prescott. "Should be on the shelf of anyone interested in the more rigorous mathematical analysis of problems in engineering." American Math Monthly. 672pp. Paperbd. $2.95

TEACH YOURSELF BOOKS

Learn the basic mathematics of science, industry, at home in less than one hour a day. These are serious, well-designed courses for fast, efficient self-study, with lesson-sized chapters, simplified teaching methods, graded exercises and problems (with answers in the back of the book), other aids. We feel these are the best elementary self-instruction manuals on the market, and back them with our usual money-back guarantee. Only $2.00 each for fine English imports.

CP680. TEACH YOURSELF ALGEBRA
307pp. Clothbound $2.00

CP681. TEACH YOURSELF GEOMETRY
334pp. Clothbound $2.00

CP682. TEACH YOURSELF TRIGONOMETRY
204pp. Clothbound $2.00

CP683. TEACH YOURSELF CALCULUS
380pp. Clothbound $2.00

CP684. TEACH YOURSELF MECHANICS
271pp. Clothbound $2.00

CP685. TEACH YOURSELF THE SLIDE RULE
207pp. Clothbound $2.00

CP237. TEACH YOURSELF HEAT ENGINES
220pp. Clothbound $2.00

CP230. TEACH YOURSELF ELECTRICITY
184pp. Clothbound $2.00

Non-Technical & Elementary Science

CP756. Just out! AN ELEMENTARY SURVEY OF CELESTIAL MECHANICS, Y. Ryabov. First American printing of unusual Russian exposition of gravity, orbits, solar system, natural and artificial satellites (including Sputnik D), and more. Only elementary math needed to follow actual computations, methods actually used. 165pp. Paperbd. $1.25

CP587. GREAT IDEAS OF MODERN MATHEMATICS: Their Nature and Use, J. Singh. Unusually successful elementary explanations of sets, groups, number theory, matrices, non-Euclidean geometry, etc., and their surprising uses in physics, biology, other fields. 320pp. Paperbd. $1.55

CP711. THE FOURTH DIMENSION SIMPLY EXPLAINED, H. Manning. Best non-technical explanations of 4th dimension available. 22 different essays. 251pp. Paperbd. $1.35

CP608-9. HISTORY OF THE WARFARE OF SCIENCE WITH THEOLOGY, A. D. White. Classic of historical scholarship by founder of Cornell U. exposes crank theories, crackpot explanations of religionists, details long struggle of scientific truth against theological orthodoxy. Thousands of little-known facts, amusing (and sometimes frightening) hypotheses developed to defend literal truth of Bible through the ages. Absolutely reputable work by great scholar whose target is human stupidity, not true spirituality. Total of 925pp. 2 vols. The set, paperbd. $3.70

WRITE FOR FREE CATALOGUE

Dover publishes the largest list in English of low-priced technical & scientific paperbacks, treatises, texts, etc., in physics, mathematics, chemistry, biology, geology, etc., at prices far below clothbound or out-of-print prices for these works. Free science catalogue sent on request.

Physics

CP745. Just out! FUNDAMENTALS OF ELECTRICITY & MAGNETISM, L. Loeb. Unusually thorough, lucid first course developed at U. of California. Over one-third of book deals with modern material not usually covered in beginning texts. 669pp. Paperbd. $2.75

CP723. New! THE THERMODYNAMICS OF ELECTRICAL PHENOMENA IN METALS and a Condensed Collection of Thermodynamical Formulas, P. W. Bridgman. Much valued intuitive approach by Nobel Prize winner. 2 works bound as one. 305pp. Paperbd. $1.65

CP720. New! PHOTOELASTICITY: PRINCIPLES & METHODS, H. Jessop, F. Harris. Best introduction to two- and three-dimensional stress-analysis techniques. 192pp. Paperbd. $2.00

CP707. ELEMENTARY PRINCIPLES IN STATISTICAL MECHANICS, J. Willard Gibbs. First enunciation of principles behind modern thermodynamics by greatest 19th century American physicist. 223pp. Paperbd. $1.45

CP754. Just out! MECHANICS, J. P. Den Hartog, Prof. of Mech. Eng., M.I.T. Exceptionally clear beginning text, noted for wide coverage, hundreds of concrete examples. "Very thoroughly recommended," Mechanical World. 471pp. Paperbd. $2.00

Chemistry, Physical Chemistry

CP700-1. New! ORGANIC CHEMISTRY, F. Whitmore. First low-priced edition of one of most valuable compilations of organic chemistry information ever assembled. "Dr. Whitmore deserves thanks and congratulations." Industrial and Engineering Chemistry. Total of 1013pp. 2 vols. The set, paperbd. $4.00

CP757. Just out! THE CHEMISTRY OF URANIUM, J. Katz, E. Rabinowitch. Reprinted through arrangement with AEC. "One of the most exhaustive critical surveys of any single element," Chemical Engineering. Indispensable lab reference on "dry" uranium chemistry. 639pp. Paperbd. $2.95

CP721-2. New! THE SCIENTIFIC PAPERS OF J. WILLARD GIBBS. Unavailable for years. Includes 300-page "Great Paper" that founded phase theory, rational thermodynamics, plus 30 other papers. 745pp. 2 vols. The set, paperbd. $4.00

ABSOLUTELY FREE

A DOVER SCIENCE SAMPLER, George Barkin, ed. A 64-page book containing interesting, self-contained passages from more than 20 Dover books explaining science or examining scientific concepts: Edwin Hubble, George Sarton, Ernst Mach, Newton, Galileo, etc. Thought-provoking, enjoyable passages on biology, physics, astronomy, many other fields of science give you hours of pleasure. Just write for it. One to a customer. No obligation to buy any other books. Free

Games & Amusements

CPI. FLATLAND, E. Abbot. Classic story of life in 2-dimensional world; also, excellent introduction to dimension concepts. 128pp. Paperbd. $1.00

CP732. Just out! DIVERSIONS & DIGRESSIONS OF LEWIS CARROLL, S. Collingwood, ed. Unabridged reprinting of rare satires intended for private circulation. 32 pages of photographs added. 385pp. Paperbd. $1.50

CP739. New! GAMES ANCIENT & ORIENTAL and How to Play them, E. Falkener. Shogi, Tamerlane's Chess, Egyptian game of the bowl, Roman latrunciles, others. Classic among game books. 235pp. Paperbd. $1.85

CP613. GO & GO-MOKU, Edward Lasker. Full principles, strategy of increasingly popular Oriental game that rivals chess. New, much-enlarged edition. 235pp. Paperbd. $1.45

CP640. MANUAL OF CHESS, Dr. Emanuel Lasker, World Champion for 25 years. Insight-packed coverage of all aspects of chess. 380pp. Paperbd. $2.00

CP528. CHESS STRATEGY, Edward Lasker. Principles, not memory; long-range play, etc., by greatest chess teacher. Taught Keres, Fine 282pp. Paperbd. $1.50

CP748. New! HOW TO SOLVE CHESS PROBLEMS, K. Howard. Over 150 choice works of internationally known chess problemist. Full solutions, principles of construction. 178pp. Paperbd. $1.00

CP796. Just out! THE COMPLETE KANO JIU-JITSU (JUDO), H. Hancock, K. Higashi. In the opinion of many experts, the finest book on the subject. 487 stopped-action photos of holds, throws; full text. 589pp. Paperbd. $2.00

Puzzles

CP736. Just out! CALIBAN'S PROBLEM BOOK: Mathematical, Inferential and Cryptographic Puzzles, H. Phillips, et al. Chief work of greatest contemporary British puzzle creator. 192pp. Paperbd. $1.25

CP731. New! MAZES & LABYRINTHS: A BOOK OF PUZZLES, W. Shepherd. Nothing else like it in print. Hours of intellectual amusement. 122pp. Paperbd. $1.00

CP498. MATHEMATICAL PUZZLES OF SAM LOYD, VOLUME I, Martin Gardner, ed. 117 ingenious creations of America's greatest originator. 187pp. Paperbd. $1.00

CP709. New! MATHEMATICAL PUZZLES OF SAM LOYD, VOLUME II, Martin Gardner, ed. For those who already have Volume I! 187pp. Paperbd. $1.00

CP367. 101 PUZZLES IN THOUGHT & LOGIC, C. Wylie. No math needed, only mental agility. Full solutions, methods of solving. 128pp. Paperbd. $1.00

CP473. AMUSEMENTS IN MATHEMATICS, H. Dudeney. One of largest collections of math puzzles anywhere. Double columns, solutions. 264pp. Paperbd. $1.25

CP198. MATHEMATICAL PUZZLES FOR BEGINNERS & ENTHUSIASTS, G. Mott-Smith. 188 puzzles on all levels of difficulty. 248pp. Paperbd. $1.00

CP493. Connoisseurs! PILLOW PROBLEMS & A TANGLED TALE, Lewis Carroll. Rare math puzzle books by author of "Alice" reprinted for first time! 280pp. Paperbd. $1.50

Humor & Entertainments

CP759. Just reprinted! ODDITIES & CURIOSITIES OF WORDS & LITERATURE, C. G. Bombaugh. New enlarged edition, edited by Martin Gardner. Almost legendary collection of literary oddities, eccentrica, amusements, acrostics, macaronic verse, famous puns, notorious misprints, literary hoaxes, etc. 368pp. Paperbd. $1.50

CP749. New! THE BAD CHILD'S BOOK OF BEASTS, MORE BEASTS FOR WORSE CHILDREN, A MORAL ALPHABET, Hilaire Belloc. Complete verse, all original illus. of famous humor favorites. 157pp. Paperbd. $1.00

CP743. New! THE CASTING AWAY OF MRS. LECKS & MRS. ALESHINE, F. Stockton. American humor classic. 239pp. Paperbd. $1.00

CP758. New! PHRASE & WORD ORIGINS: A Study of Familiar Expressions, A Holt. "Let George do it," "By hook or by crook," 1500 others traced to often surprising sources. New, enlarged edition. 259pp. Paperbd. $1.35

CP713. Just out! PAPER FOLDING FOR BEGINNERS, W. Murray, F. Rigney. Create scores of beautiful, unusual, useful objects and figures just by folding paper. Easiest-to-follow book on Japanese art of Origami ever written. 95pp Paperbd. $1.00

CP487. THE DEVIL'S DICTIONARY, Ambrose Bierce. "Some of the most gorgeous witticisms in the English language," H. L. Mencken. 144pp. Paperbd. $1.00

CP522. HOW TO TELL THE BIRDS FROM THE FLOWERS, R. Wood. Classic puns in drawings and verse by eminent physicist. 64pp. Paperbd. 75¢

CP602. THE WIT & HUMOR OF OSCAR WILDE, A. Redman, ed. 1,000 quotable epigrams of England's wittiest man. 260pp. Paperbd. $1.00

CP698. BARON MUNCHAUSEN, R. Raspe. Only complete edition in print. Carswell edition, with 90 Doré illustrations. 233pp. Paperbd. $1.00

CP691. THE WIZARD OF OZ, L. Baum. Only edition with all 153 original Denslow drawings (the ones you remember) in full color. 272pp. Paperbd. $1.45

Dept. CP353, Dover Publications, Inc.
180 Variek Street, New York 14, New York
Please send me the following books (give key numbers):

I am enclosing $_____ in full payment. Payment in full must accompany all orders, except those from libraries and public institutions, who may be billed. Please add 10¢ per book for handling and postage on orders less than $5.00. Please print

Name _____

Address _____

City_____ Zone____ State_____

GUARANTEE: All Dover books are unconditionally guaranteed, and may be returned within 10 days for full and complete cash refund.

B/A All-Dielectric INTERFERENCE FILTERS

Baird-Atomic announces the introduction of their radically improved Ultra-violet Filters and all-dielectric Visible Spectrum Interference Filters.

The new 'block shape' ⎍ passband in the Visible Spectrum Filters enables the user to obtain the greatest degree of spectral purity.

If the filter you require is not available in stock, normal delivery time is within thirty to thirty-five days.

Standard filter sizes are 1" x 1" and 2" x 2"; other sizes and shapes are available on special order. Write for your copy of our new filter brochure.

Engineers and scientists — investigate challenging opportunities with Baird-Atomic. Write Industrial Relations Department.

Visible Spectrum

- 4000Å - 8000Å
- New block shape ⎍ passband
- Absorption filters and or evaporated blocking components provide for maximum blocking, reduced thickness, and improved signal-to-noise ratio
- Transmission outside of passband: under 0.1%
- Half bandwidths from 1.6 Å to 1600Å
- Total transmission from fully blocked filter: up to 70%
- Blocking — complete on low side — high side blocking to at least 8000Å (Additional blocking at extra cost)

Ultraviolet Spectrum

- 2100Å to 3400Å and 3900Å to 3999Å

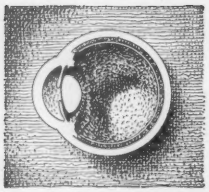
BAIRD-ATOMIC, INC.

33 university road · cambridge 38, mass.

ADVANCED OPTICS AND ELECTRONICS . . . SERVING SCIENCE

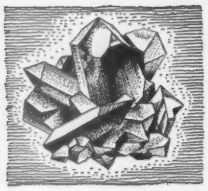
IT HAPPENED THIS MONTH...

a glance at yesterday in relation to today



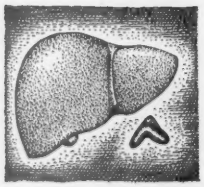
IN MAY—(1874)—James Clerk Maxwell philosophizes about colour vision. "I have here . . . a picture of the structure upon which the light falls at the back of the eye. There is a minute structure of bodies like rods and cones or pegs, and it is conceivable that the mode in which we become aware of the shapes of things is by a consciousness which differs according to the particular rods on the ends of which the light falls, just as the pattern formed by a Jacquard loom depends on the mode in which the perforated cards act on the system of movable rods in that machine. In the eye we have on the one hand light falling on this wonderful structure, and on the other hand we have the sensation of sight. We cannot compare these two things; they belong to opposite categories. The whole of Metaphysics lies like a great gulf between them."[1]

While the gulf between light and sight remains, it is narrowing; we know more about the intermediate processes. DPN has been shown to play an important role in the metabolic transformations triggered by light-activated bleaching of the visual purple or rhodopsin. ATP provides the chemical energy for the neurophysiological mechanisms that follow. For workers who are reducing the gulf still further, Schwarz BioResearch supplies DPN, ATP, and other important metabolic cofactors such as adenylic acid, cocarboxylase, flavin adenine dinucleotide, guanosine diphosphate, and guanosine triphosphate.



IN MAY—(1934)—Max Bergmann has yet to leave Dresden for the United States, but his papers are already appearing in American journals. This month, in *Science*, he discusses the use of carbobenzoxy amino acids in the synthesis of peptides. These "beautiful crystalline" substances can easily be transformed into their acid chlorides or azides, and the latter in turn condensed with other amino acids to yield carbobenzoxy peptides. The carbobenzoxy residue can then be readily eliminated without using a hydrolytic agent and thereby without risking a split in the peptide bond. Since carbobenzoxy amino acids are surprisingly stable to racemizing influences, it is now simple to prepare many optically active peptides previously considered practically inaccessible.[2]

It is an even simpler matter to order many optically active peptides. Schwarz BioResearch is the exclusive distributor for more than 40 carbobenzoxy amino acid derivatives produced by the Yeda Research and Development Company, Ltd. at the Weizmann Institute of Science in Israel. Yeda also produces a large number of polyamino acids and O^{18} compounds. A catalog is yours on request.



IN MAY—(1956)—Lowe and Rand discuss the ability of cortisone to produce certain changes in liver metabolism of RNA in rats.[3] They suggest that a variant RNA may be synthesized under the influence of cortisone or that normal RNA may be converted to this variant. This "new" RNA differs in solubility properties and rate of P^{32} incorporation. One of the more significant aspects of this variation is that it may be unable to act as a template for normal protein synthesis.

The influence of drugs and hormones on nucleic acid metabolism is of enormous practical interest in medical and biological research. Endocrinologists, pharmacologists, and others working in this field make increasing use of the full line of nucleic acid compounds supplied by Schwarz BioResearch: DNA, RNA, nucleate salts, nucleotides, nucleosides, purines and pyrimidines. Many have been labeled with C^{14} or H^3. Write for our catalog and price list.

1. Maxwell, J. C.: On colour vision. Nature 4:13 (May) 1874. 2. Bergmann, M.: Synthesis and degradation of proteins in the laboratory and in metabolism. Science 79:218 (May 18) 1934. 3. Lowe, C. U., and Rand, R. N.: Alterations in biochemical composition and ribonucleic acid metabolism induced in rat liver by cortisone. J. Biophys. and Biochem. Cytology 2:331 (May 25) 1956.

SCHWARZ BIORESEARCH, INC. · Dept. 5B · Mount Vernon, New York

BIOCHEMICALS · RADIOCHEMICALS · PHARMACEUTICALS *for research, for medicine, for industry*

PRECISION SYRINGES FROM 1ul to 500ul

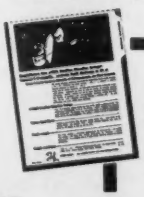
Hamilton Microliter Syringes meet the demands of precision analysis with accuracy, greater sensitivity, speed and minute—yet accurate discharge. By meeting critical demands they have become the standard in gas chromatography, chemistry, biology and medicine.

Each syringe is individually fitted with stainless steel plungers in precision bore NC glass to assure leak tight performance . . . even when tested with water at 150 psi.

MODEL	SIZE	PRICE
#7001 N	1.0 ul	$35.00
#701 N	10.0 ul	18.00
#705 N	50.0 ul	18.00
#710 N	100.0 ul	18.00
#725 N	250.0 ul	18.00
#750 N	500.0 ul	18.00

***Order direct* . . . also available through your supply house.**

FREE LITERATURE on Hamilton Microliter Syringes, with complete information, write today . . .



HAMILTON COMPANY, INC.

PRECISION MEASURING EQUIPMENT
FOR CLINICAL AND CHEMICAL RESEARCH

Hamilton Company, Inc.
P.O. Box 307-K
Whittier, California

Send me a copy of your equipment brochure.

Name _____

_____

Attach to company letterhead and mail

Now you can do ALL your sample counting

AUTOMATICALLY...with the New *Tracerlab*

multi/matic Sample Changer

The SC-101 Manual Flow Counter with ultra-thin Mono/mol Window Detector.

New FD Series Flow Counter with the ultra-thin Mono/mol Window features plug-in assembly.

Fifty sample capacity . . . any size up to two inch . . . any type of detector (Scintillation, Flow Counters, GM Tube) . . . simple one-knob operation . . . these exclusive advantages plus low initial cost and low operating costs . . . are all yours in the outstanding new Tracerlab MULTI/MATIC Sample Counting System.

Only from Tracerlab — the world's largest and *first* manufacturer of Sample Changers could you expect — and get — such a revolutionary new system.

The New SC-100 MULTI/MATIC Sample Changer provides positive, accurate positioning of samples. Samples are readily accessible because they are loaded and driven on a horizontal plane (in contrast to tower or stack types). Automatic recycling of a single sample, automatic bypass of empty sample positions, automatic recycling to the starting position plus the ability to operate with all types of detectors are other features of this most versatile new Tracerlab development.

The New Tracerlab FD-1 and FD-2 Flow Counters feature the ultra-thin Tracerlab Mono/mol window (less than 125$\mu g/cm^2$). These low cost units, available in 1″ or 2″ window diameters plug in to a common shield and feature low background . . . excellent plateau characteristics . . . very low gas consumption and will operate with a wide variety of counting gases including helium-isobutane, argon-methane, methane or natural gas.

The New Tracerlab SH-1 Shield operates with either the automatic changer or the SC-101 Manual Changer pictured. It accommodates both the 1″ and 2″ FD Series Flow Counters, windowless flow counters, P-20D Scintillation Detectors or standard GM detectors. Convenient handles make it easy to insert or remove from any changer, shield thickness of 2 inches of lead provides low reproducible backgrounds.

The Tracerlab MULTI/MATIC Sample Counting System when combined with other Tracer/matic components . . . scalers, time and count printers, or time, count and CPM printers . . . provides more specific sample information than any other system.

For complete specifications on the new low cost, economical-to-operate Tracerlab MULTI/MATIC Sample Changer write for Bulletin M.

Tracerlab Tracerlab Kellogg

1601 Trapelo Road, Waltham 54, Massachusetts

2030 Wright Avenue, Richmond 3, California

5 May 1961, Volume 133, Number 3462

SCIENCE

AMERICAN ASSOCIATION
FOR THE
ADVANCEMENT OF SCIENCE

Board of Directors

CHAUNCEY D. LEAKE, *Retiring President, Chairman*
THOMAS PARK, *President*
PAUL M. GROSS, *President Elect*

HARRISON BROWN — DON K. PRICE
HENRY EYRING — ALFRED S. ROMER
H. BENTLEY GLASS — WILLIAM W. RUBEY
MARGARET MEAD — ALAN T. WATERMAN
PAUL A. SCHERER, *Treasurer*
DAEL WOLFLE, *Executive Officer*

Editorial Board

KONRAD B. KRAUSKOPF — H. BURR STEINBACH
EDWIN M. LERNER — WILLIAM L. STRAUS, JR.
PHILIP M. MORSE — EDWARD L. TATUM

Editorial Staff

DAEL WOLFLE, *Publisher* — HANS NUSSBAUM, *Business Manager*

GRAHAM DUSHANE, *Editor*

JOSEPH TURNER, *Associate Editor* — ROBERT V. ORMES, *Managing Editor*

ELLEN E. MURPHY, *Assistant Editor*

NANCY TEIMOURIAN, *Assistant to the Editor*

News: HOWARD MARGOLIS

Book Reviews: SARAH S. DEES

Editorial Assistants: NANCY S. HAMILTON, EDGAR C. RICH, BARBARA SUTHERLAND, CONRAD YUNG-KWAI

Staff Assistants: GENEVIEVE M. KIRBY, PATRICIA D. PADDOCK, LOIS W. WOODWORTH

Advertising Staff

EARL J. SCHERAGO, *Director*

BERNICE SCHWARTZ, *Production Manager*

Sales: RICHARD L. CHARLES (New York, N.Y., PE 6-1858); C. RICHARD CALLIS (Old Bridge, N.J., CL 4-3680); HERBERT BURKLUND (Chicago, Ill., DE 7-4973); DILLENBECK-GALAVAN (Los Angeles, Calif., DU 5-3991)

SCIENCE, now combined with THE SCIENTIFIC MONTHLY, is published each Friday by the American Association for the Advancement of Science at National Publishing Company, Washington, D.C. SCIENCE is indexed in the *Reader's Guide to Periodical Literature.*

Editorial correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts, see *Science* **125**, 16 (4 Jan. 1957).

Advertising correspondence should be addressed to SCIENCE, Room 1740, 11 West 42 St., New York 36, N.Y.

Change of address notification should be sent to 1515 Massachusetts Ave., NW, Washington 5, D.C., 4 weeks in advance. If possible, furnish an address label from a recent issue. Give both old and new addresses, including zone numbers, if any.

Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢. Single copies, 35¢. Cable address: Advancesci, Washington.

Copyright © 1961 by the American Association for the Advancement of Science.

How Helpful Is Freedom?

Because science depends so immediately on freedom of inquiry, partisans of political freedom are tempted to believe that democracy, whatever its shortcomings in producing space spectaculars, must in the end be the form of government best designed to produce pure science. The argument is that the individual must be free to propose hypotheses and test them. Heinrich Schliemann in the 19th century, for example, had to be free both to believe that Hissarlik was the site of Homer's Troy and to go to the spot and dig. If some government had held, as a consequence of its metaphysics, that Troy never existed, or if some government had feared that the practice of digging for Troy might lead to a penchant for digging into other matters as well, then there would have been no archeological confirmation of the Achaean heroes.

This argument is sound, but the implications for the superiority of democracy as an environment for science are limited. For one thing, freedom by itself is not enough. Although Schliemann may have been free to dig as deeply as he liked, he had first to amass the fortune necessary to finance his digging. But what is more interesting is that science has other characteristics besides the need for freedom, and these other characteristics suggest that this need if deep may not be broad.

Besides the posing and testing of hypotheses, science is also characterized by its procedure of not attempting to answer all questions at once. Scientific knowledge is possible because it is compartmentalized, because it is possible to discover truths about one question and at the same time ignore other questions. Hydrodynamics, for example, can be studied independently of thermodynamics, and the two disciplines together have nothing to say about the sensory qualities of a cold drink of water on a hot day. It may well be that freedom of the most complete sort in one part of knowledge is entirely compatible with total bondage in another part.

Research in its later stages, it is true, has a way of breaking down the very barriers that made earlier progress possible. If science is compartmentalized, it also strives toward unity. The turn of the century saw how increased knowledge about the structure of the atom broke down the barriers between chemistry and physics, and we are now watching our growing knowledge of the structure of the gene break down the barriers between biology and the physical sciences. But unity, in turn, produces new compartments. If where once stood a fence there is now a house, the house itself is a kind of enclosure and within it lives a new group of specialists.

One point about a totalitarian government is clear. To the extent that it chooses to meddle with the methods of research, or to dictate the results of research, science will be the loser. But without claiming that the pull in science toward specialization is somehow stronger than the pull toward unity, it is still possible to say that freedom to study a particular problem is not immediately dependent on freedom to study every problem. What has yet to be fully determined is what happens when a totalitarian government chooses to support some parts of science vigorously and intelligently, because it sees the achievements of science as contributing to its own greater glory.—J.T.

Hours of analyses in easy minutes

BAUSCH & LOMB Spectronic 20 COLORIMETER

This best-selling laboratory workhorse (above) gives you split-second readings, easy as tuning your radio. No color filters to fuss with. Just turn a dial for the right wavelength for each procedure. Narrow band pass (only 20 mu!) assures highest spectral purity. You get the double value of a colorimeter and a spectrophotometer in one trouble-free unit . . . with prices starting at only $255!

BAUSCH & LOMB Serum Protein Meter

Now you can analyze protein in one-tenth the time of other methods. Centrifuge the sample. Put it on the Serum Protein Meter. Read the results, in protein grams per 100 milliliters, on the scale. Just like that! Any busy lab will write off the low cost of this super-speed unit in a matter of days—only $175!

BAUSCH & LOMB
SINCE 1853

Made in America, to the world's highest standards.

BAUSCH & LOMB INCORPORATED
64217 Bausch Street, Rochester 2, N.Y.

I'd like a demonstration of:
☐ Serum Protein Meter
☐ Spectronic 20 Colorimeter

Please send catalog on:
☐ Serum Protein Meter—D-2013
☐ Spectronic 20 Colorimeter—D-266

Name .....

Title .....

Professional Address .....

5 May 1961, Volume 133, Number 3462 SCIENCE

CURRENT PROBLEMS IN RESEARCH

Information Theory

A brief survey is made of the recent developments and the current status of information theory.

H. H. Goldstine

It is with considerable diffidence that I attempt to discuss more or less authoritatively a subject that has been conceived and perfected by communication engineers and that is both an interesting and a novel application of mathematics. In the dozen years since its inception by Shannon, information theory has reached a state of perfection and completeness in which it is likely to remain for some time. At least this is the impression I have received from talking with some men who are specialists in this and related areas. This statement must, of course, be accepted with suitable caveats, since it sounds much like similar statements, made in the past by others, that later required extensive modification. But it does seem to me that an equilibrium has more or less been reached in the fundamentals of the subject, so that the mathematician can reasonably undertake a survey of the situation.

Entropy

Before discussing the newest developments, let me review briefly the elements of information theory (*1*). This subject was initiated in a tentative way by various authors (*2*) in the 1920's and ultimately developed as a comprehensive subject in 1948 by C. E. Shannon (*3*) in a now classic paper in the *Bell System Technical Journal*. Since then there has been considerable activity in the field. But before discussing the more recent activity, let me sketch some of Shannon's work. He started with the very plausible assumption that it is desirable to have a means of measuring the amount of information present in a given situation. He was able to construct in most cases of importance such a measure. Consider, for the sake of simplicity, an event chosen from a finite number of possible events. If all these events are a priori equiprobable, then the number, n, of them can be used as a measure of the amount of information present. There are, however, certain cogent reasons why it is better not to use n but to use, instead, the logarithm of n. To understand this reason, suppose one has two systems, one of which has m and the other n possible, equiprobable events. If one then considers the sum of the two systems, the number of possible events is now mn. It would be desirable that the measure of information content be not multiplicative but additive. Thus, one desires

$$f(mn) = f(m) + f(n)$$

and also if $m > n$, then in some sense the system with m events should contain more information than the one with n events; that is,

$$f(m) > f(n)$$

provided that $m > n$. It is an easy technical task to show that under these conditions

$$f(n) = C \ln n$$

for some positive constant C. Finally, it is customary to take the smallest non-zero amount of information as the unit of the system. But this smallest quantum is, of course, the binary digit, and thus

$$f(n) = \log_2 n$$

In the case that not all events are equally probable, it is still possible to define a measure for the information content for the system. To do this, suppose that the events have probabilities $p_1, p_2, \ldots, p_n$; then the "entropy" or measure of information content is by definition

$$H = -\Sigma_{i=1}^{n} p_i \log_2 p_i$$

Note that this measure is given in binary digits. By way of illustration, note that a decimal digit represents $\log_2 10 = 3.3$ binary digits, and a letter from our alphabet, $\log_2 26 = 4.7$ binary digits. If the $p_1, p_2, \ldots, p_n$ are all equal to $1/n$, then our last definition reduces to $\log_2 n$, as it should. If Shannon's axioms are slightly modified one obtains the concepts of information introduced much earlier by Fisher (*4*), in 1925; and if one makes the axioms slightly weaker, one obtains both their concepts, as well as other similar ones. This fact was shown in 1951 by Schutzenberger (*5*).

The introduction of the notion of an entropy into information theory establishes a close connection between thermodynamical systems and information-theoretical ones. This, according to von Neumann, is due to the fact that Boltzmann's definition of entropy is in terms of the number of a priori equiprobable states compatible with the macroscopic description of the state—that is, it corresponds to the amount of microscopic information missing in the macroscopic description.

Coding Theorem

Shannon's theory is principally concerned with those problems of communications engineering that naturally

The author is affiliated with the IBM Research Center, Yorktown Heights, N.Y. This article is adapted from a lecture delivered 28 December 1960 before the AAAS meeting in New York.

arise in the transmission of information over channels, and in particular over noisy ones—that is, ones where it is not certain that the information received is identical to that transmitted. It is clear that one can give an intuitively reasonable notion of rate of transmission of information and also of the capacity of a channel. To do these things, consider an arbitrary time T and let $N(T)$ be the number of distinct messages of duration T; then $[\log_2 N(T)]/T$ can be used to measure the *rate of transmission of information*, and the limit of this ratio, as T approaches infinity (it exists under a wide class of conditions), measures the capacity of the channel. Thus, in some sense the channel capacity is the maximum rate at which it is possible to communicate information over the channel.

One of Shannon's most remarkable results is the so-called coding theorem for noisy channels. This theorem, roughly speaking, guarantees that the channel capacity as just defined is precisely the maximum rate at which it is possible to receive information with arbitrarily high reliability (Below I state this remarkable theorem precisely). This is, in my opinion, one of the most surprising and important results in the entire theory. A priori, one might imagine that as the noise in a channel increases, the rate at which one can transmit information reliably down the channel would necessarily decrease to zero.

To see why this theorem is so noteworthy, let us consider how one might go about ensuring reliable transmission in the presence of noise. The most obvious thing to do is to repeat the message enough times to guarantee reliable reception. It can be shown that the price paid by this method for a very high reliability is a vanishingly low rate of transmission. For example, one can repeat each digit an odd number of times and decide at the receiver, by a majority rule, what was transmitted. It is clear how the rate of transmission goes down, and it is not too difficult to estimate how the reliability goes up as the number of iterations increases. This and other naive attacks all seem to lead to the same predicament, and this is the reason why Shannon's result is both so beautiful and so unexpected. Unfortunately, now, a dozen years after the discovery of the theorem, we still do not know how to achieve in general the result guaranteed by the theorem. This is not due to a desire for a result of great mathematical generality or a desire for elegance. Even in the case of the simplest nontrivial channel it is not known in complete detail how to proceed.

A little later we will return to this problem, which will lead us into that branch of information theory known as coding theory. Before proceeding, it is perhaps desirable to mention that Elias devised an iterated scheme of coding of considerable theoretical interest which achieves as high a degree of reliability as one desires and yet does not result in an arbitrarily low rate of transmission. It does not, it is true, achieve a rate of transmission equal to the channel capacity, but it has two interesting properties: for a fixed rate, the reliability can be increased at the cost of coding delay; for a fixed delay, the reliability can be increased at the cost of transmission rate. In a quite real sense Elias's scheme achieves its goal by introducing redundancy, much as natural language does (*6*).

Probabilistic Logics

Before going into more detail on modern developments and current status in information theory, I should like to discuss a different but closely related problem originally formulated in 1952 by von Neumann in a series of lectures at California Institute of Technology (*7*) and later reconsidered by Shannon and E. F. Moore (*8*), in 1956. Here the problem is not how to transmit data down noisy channels in the presence of noise but rather how to carry out logical functions in the presence of noise. That is, von Neumann inquired whether a reliable automaton could be designed in which logical elements could be used which were not perfect in the sense that each had a certain probability of malfunctioning. For his building blocks he used majority organs, whereas Moore and Shannon used relays.

The result is most remarkable and very elegant: It is possible to organize components which are individually unreliable into an automaton capable of arbitrarily high reliability. This is, to me, a result like Shannon's coding theorem for noisy channels in that it is, a priori, not obvious that the opposite is not true. Perhaps it is worth saying a few words to indicate how von Neumann achieved his result. He considered a majority organ, which is a three-input, one-output device where the output is the majority of the inputs. Suppose that we have such a majority organ with probability e of being in error and with probabilities f_1, f_2, f_3 that the input lines carry wrong signals. Then clearly $e + f_1 + f_2 + f_3$ is an upper bound for the probability that the output line is in error. From this we might conclude that the entire program is hopeless. However, we can manifestly obtain a much better upper bound under reasonable assumptions—namely, (i) the probabilities of error are independent, and (ii) under normal conditions all lines should be in the same state. Then the probability of at least two inputs being in error is clearly $P = f_1f_2\ (1 - f_3) + f_1f_3\ (1 - f_2) + f_2f_3\ (1 - f_1) + f_1f_2f_3 = f_1f_2 + f_1f_3 + f_2f_3 - 2f_1f_2f_3$. Thus, the probability Q of the output being in error is $(1 - e)\ P + e\ (1 - P) = e + (1 - 2e)\ P$. Now, if all $f_i \leqq f$, then $e + 3f$ is always an upper bound for Q and $e + (1 - 2e)\ (3f^2 - 2f^3) \leqq e + 3f^2$ is a better one, since $e + 3f^2 < f$ is possible. (In fact, for $f \sim e + 3e^2$, the two sides of the inequality are roughly equal.) If the conditions outlined above can always be maintained, then errors can indeed be kept under control. To do this without introducing a number of components that is increasing exponentially with the "logical depth" of the function—that is, the number of elements such as relays, tubes, and transistors, arranged in cascade fashion—von Neumann resorted to a very elegant trick. This consisted of transmitting all messages over N lines in parallel. A fiducial level $\Delta < \frac{1}{2}$ is chosen beforehand so that if ΔN lines, or less, all are stimulated, it is decreed that this is the one type message, say a 0, and if $(1 - \Delta)\ N$ or more are stimulated, then it is the other type, say a 1. Any other number is considered a malfunction of the system. Space does not allow me to go into details beyond noting the main result, which is roughly this: the probability of a malfunction is approximately

$$(6.4/\sqrt{N})\ 10^{-2.07N/10,000}$$

where N is the number of lines in a bundle.

The drawback both in von Neumann's and in Moore-Shannon's work lies not in the concept or in any lack of beauty and depth of the analysis; in fact, on the contrary, these papers are both brilliant. The difficulty is that to achieve an arbitrarily low probability of a malfunction one must increase the size of the assemblage beyond bounds.

Coding Theory

Before going on to my main task of reporting on the current status of information theory, I think it would be desirable to say a few words on coding theory. I alluded most briefly to this topic in discussing Shannon's coding theorem for noisy channels. Recall that this theorem guarantees the existence of a coding of the input information and a decoding of the output information from the channel with an arbitrarily low probability of error, provided that the entropy of the information per unit of time is less than the channel capacity; for the entropy per unit of time in excess of the capacity, it is impossible. Now the essential task of coding theory is to discover these codings and decodings. This is one of the most important present-day areas of interest in the subject. Perhaps it would be well to say a few words on this topic, which received its initial impetus in a now classic paper by Hamming (*9*) in the 1950 *Bell System Technical Journal*. Since then a great many others have been instrumental in carrying forward the development of the theory (see references). It is not out of place, however, to mention Slepian (*10*), Bose and Ray-Chaudhuri (*11*), and Elias (*6*) as four of the leaders in the field.

To discuss coding one must realize that to achieve any sort of reliability one must introduce redundancy. In general, the problem faced by the coder is how to introduce redundancy into the system as efficiently as possible. In the next few paragraphs I describe briefly and geometrically some facts related to coding theory.

Let us consider all possible sequences of n binary digits. There are 2^n of these, and they form the vertices of the unit cube in an n-dimensional space. A code then consists of a designation of some subset of these vertices, and the received message is a transformation of this set into another set of these vertices. That is, it is a mapping of vertices onto vertices. If there is no error in reception, then the transformation is the identity, whereas if one error is introduced, the transformation carries a vertex into one an edge away; if r errors occur, the transformed point is r edges away.

It is not difficult to see that the transformed points are most probably near the input point and least probably far away. This suggests the means of decoding: one can associate with each vertex a set of vertices which are in an obvious sense quite close to the given vertex; the decoding consists of systematically classifying all these "closest" neighbors as being identical with the given vertex. These decoding schemes are called "maximum likelihood detectors." Two very important notions in this subject are group and parity check codes. Slepian showed them to be equivalent. The set of all binary sequences of length n form a group under addition modulo 2—the addition is element by element. (For this group the zero element is of course the sequence of all zeros.) Then a group code is any subset of this group that forms a subgroup.

These codes are of especial interest and permit easy definition of the "closest neighbors" of a vertex. They are known to be equivalent to parity check codes. Such codes are defined by assigning some digits in a sequence to be for information and keeping the remaining ones as check digits.

Another development in coding theory of a quite interesting nature is that concerned with correcting bursts of errors. The basic assumption made in this analysis is that in data transmission the noise on the channel is not randomly distributed but occurs in bursts. The problem of course is to construct codes which make it safe to transmit information in the presence of such noise bursts.

New Directions

Having said all these more or less preliminary things, I now turn more explicity to the modern developments and attempt to indicate, in a brief way, the course the subject has had. Once again it is worth remarking that such a survey as this necessarily ignores some work and also gives emphasis to other developments in a highly subjective fashion; it is to be hoped that time will show that the choices made are wise ones.

From 1948 until perhaps 1954 or 1955, men working in information theory were primarily interested in understanding and consolidating the pioneering results of Shannon. In some sense this period was more or less at an end by 1954–1955, when Feinstein (*12*) first established Shannon's conjectured theorem on transmission down noisy channels, and when Slepian introduced the notion of group codes. Not unnaturally, one of the main directions of post-1955 information theory has been to consolidate the subject more and more closely into the fold of "conventional mathematics."

One of the important directions of research in information theory has arisen from the esthetic desires of the mathematician to reformulate results from science and engineering into "polite" mathematical language. This was done in a notable way with the coding theorem of Shannon by the late A. Khinchin (*13*), and the result was a most remarkable and unexpected limit theorem in probability. In the simplest case the theorem is concerned with two sets of sequences of binary digits—the emitted and the received symbols—and with a non-negative function of two binary digits. (This function enables one to construct various conditional probabilities that arise.) Then the formulation of the coding theorem of Wolfowitz (*14*) ensures the existence of a positive channel capacity C such that for every a between 0 and 1, (i) there exists a positive constant k such that for every n there is a code with probability of error less than a and length at least

$$2^{nC} - k\sqrt{n}$$

and (ii) there exists a positive constant k' such that for every n there does not exist a code with probability of error less than a and length in excess of

$$2^{nC} + k'\sqrt{n}$$

The notion of the length of a code is not quite a self-evident one, and it might be well to explain in detail its meaning, particularly since this helps to illuminate the significance of the theorem. To do this, we will consider sequences $u = (x_1, x_2, \ldots, x_n)$, each of n binary digits. Now the channel down which each digit is transmitted carries out a chance experiment on each of these digits in turn. The experiment is such that its outcome, when performed on x_i, is 1 with probability p_i and 0 with probability $1 - p_i$. The sequence $v(u) = [y_1(u), y_2(u), \ldots, y_n(u)]$ of outcomes is again a sequence of binary digits. A sequence v of n binary digits is a possible received sequence in case, for some transmitted sequence u, the probability of v being $v(u)$ is not zero.

We can now follow Wolfowitz and define a code of length N corresponding to a positive number a as a set $[(u_1, A_1), (u_2, A_2), \ldots, (u_N, A_N)]$ where each u_i $(i = 1, 2, \ldots, N)$ is a transmitted sequence, where each A_i

($i = 1, 2, \ldots, N$) is itself a collection of sequences of n binary digits, where the probability that v (u_i) is in A_i must not be less than $1 - a$ for $i = 1, 2, \ldots, N$, and finally where the A_1, A_2, . . ., A_N are disjoint. For such codes the i-th word in a message is taken to be u_i; the recipient of a message now decodes in this manner: if he receives any sequence in A_j, he interprets this to mean that u_j was transmitted. In case the sequence is not in the union of A_1, A_2, . . ., A_N, the result is completely ambiguous. Thus, the probability that a word can be correctly received is not less than $1 - a$. The ratio $(\log_2 N)/n$ is called the rate of transmission.

The study of this theorem of Shannon's has led researchers in two general directions. One group has worked on simplifying the proof of the theorem and casting the result itself into a more general probabilistic setting. The proofs depend upon combinatorial theorems and are now quite elementary in nature. The other group has been concerned with generalizing the theorem by relaxing the requirements of the hypotheses. The original theorem was concerned with discrete channels without memory—that is, discrete channels where no prior transmission can effect a subsequent one. Subsequent researches have been in the direction of relaxing these restrictions to include channels with finite memory; channels with a continuum of received symbols instead of the 0, 1 of a binary channel; channels with the channel probability function not completely known to the receiver, to the sender, or to either of them; and so on. Work in this direction has been done by Feinstein (*12*), Wolfowitz (*14*), Blackwell, Breiman, and Thomasian (*15*), McMillan (*16*), and others. Apparently, part 2 of the theorem has been the subject of much interest since the surprise occasioned by the possibility of coding at a rate $(\log_2 N)/n$ less than C perhaps made some people assume without proof the impossibility of coding at a higher rate. The net result of these two lines of work has been to produce a much more elegant theorem than that originally formulated, set in a more abstract and general milieu, with a considerably simpler proof than it originally had.

The second broad line of research in information theory has been in the field of coding itself. Suppose the total number of words in the sender's—and the receiver's—dictionary is N. These words may be enumerated as 1, 2, . . ., N, and then if there were no noise on the channel, they could be coded for transmission down a binary channel into sequences of length $n = \log_2 N$. If this were done, then the rate of transmission would be 1, which is the optimal value. However, when there is noise on the channel, redundancy must be introduced—that is, n must be chosen to be greater than $\log_2 N$, and the rate of transmission drops. How large n must be depends of course upon the channel capacity. In general it is clear that n must be large enough so that all words in coded form are quite different, to enable the receiver to distinguish them unambiguously.

As I mentioned above, instead of attempting optimal codings, workers in the field have devoted their efforts to constructing codes which are guaranteed to be safe against various types of disturbances. For example, Hamming in his original paper exhibited a code that can detect two errors and correct one of them. Recently Bose and a student, Ray-Chaudhuri, using theory of finite fields, gave a constructive method for finding a t-error correcting code for messages of length $n = 2^m - 1$, using at most mt parity symbols.

Bursts of errors are a frequent source of difficulty, and codes to combat this type of noise burst have been devised by Abramson (*17*), Fire (*18*), Meggitt (*19*), Muller (*20*), and others. These codes correct errors when they occur in adjacent positions.

They are all examples of Slepian group codes. Other particularly interesting types of such codes are the so-called cyclic ones—that is, ones where cyclic permutations of code words are again code words. Such codes have been studied by W. W. Peterson (*21*), Melas (*22*), Meggitt (*19*), Elspas (*23*), and Abramson. Most codes that have been discussed here are in fact of this kind. They permit relatively easy encoding and decoding. In these cases one does not need large dictionaries but can encode or decode by analytical means.

There was a period in which interest in codes dropped off, but with the advent of ever-larger computers there has been a substantial revival of interest in the subject. An interesting study would be that of contrasting the economics of establishing additional transatlantic or continental communication lines with the economics of installing very large computers to act as coders and decoders for messages. (Of course, the need for very large and very fast computers arises from the fact that the coding and decoding involve problems either of very large tables or of very rapid analytical calculations.) As far as I know, no such study has as yet been made.

A third line of research is that of Elias (*24*), to which I have alluded above, in which he has shown that any attempt to subject to the methods of information theory the von Neumann or Shannon-Moore approach to computers and automata either is impossible or will require at the least a very deep and penetrating analysis. His result, while a negative one, is nonetheless a landmark in the field. It indicates clearly that no coding theorem-like result can be expected except perhaps at a quite profound and as yet unknown level of understanding and sophistication.

Finally, a fourth line of research has been that of applying information theory to other disciplines. In general, most of these efforts have consisted of applying the concept of entropy to different situations. One of the most notable of these applications has been that of a U.S.S.R. school under the leadership of one of the great Russian probabilists, Kolmogoroff. He has enthusiastically promoted the role of entropy in probability theory. The most striking results have been achieved not in the field of information theory but, remarkably enough, in ergodic theory. This subject grew out of studies of analytical dynamics by G. D. Birkhoff (*25*) and von Neumann (*26*) over 30 years ago. Von Neumann had brought this subject to some state of completeness but had left a number of famous unsolved problems. Kolmogoroff and two of his students, Sinai and Rohlin (*27*), within the last several years have solved many of these problems quite simply by introducing the notion of entropy into the subject and showing that it is still another invariant. Work on seeing if still other invariants exist continues. Halmos and Kakutani are two of the key figures in this field in the United States today.

Last year Linnik (*28*) established the central limit theorem of probability under Lindberg's condition, using notions of information theory. Also Gelfand (*29*), Yaglom, and other Russian

mathematicians have been applying entropy definitions to ever more general classes of stochastic processes and obtaining limit theorems on sums of independent random variables. This work really is much closer to probability theory than to information theory.

The concepts and results of information theory, together with those of Fourier series theory, have now become the basic themes of most work in communication theory today.

The only other applications I shall mention are two attributable to Mandelbrot (*30*). One lies in the field of statistical thermodynamics; in it he exploited a suggestion of Szilard's to apply various statistical concepts to thermodynamics. The other lies in the field of linguistics and concerns, in particular, stochastic properties of language. Mandelbrot considered discourse as a sequence of letters and words with various Markoff-type chain relationships between them. This leads to some quite unusual theorems in probability that have received empirical verification.

There have also been applications of information theory to biology, psychology, science, and statistics, but space does not permit me to go into these. Fortunately, however, books are available on these subjects, by Attneave (*31*), Brillouin (*32*), Kullback (*33*), and Quastler (*34*).

References and Notes

1. F. L. Stumpers has compiled a very complete bibliography on information theory, which has been published in various years in the *IRE Transactions on Information Theory* ["A bibliography of information theory," *IRE Trans. on Inform. Theory* **PGIT-2**, 1 (1953); **IT-1**, 31, 40 (1955); **IT-3**, 150 (1957)]. Forthcoming books by W. W. Peterson and J. Wolfowitz will have quite up-to-date bibliographies on the entire subject.
2. L. Szilard, *Z. Phys.* **32**, 753 (1925).
3. C. E. Shannon, *Bell System Tech. J.* **27**, 379, 623 (1948).
4. R. A. Fisher, *Proc. Cambridge Phil. Soc.* **22**, 700 (1925); *Contributions to Mathematical Statistics* (Wiley, New York, 1950).
5. M. P. Schutzenberger, *Compt. rend.* **232**, 925 (1951).
6. P. Elias, *IRE Trans. on Inform. Theory* **PGIT-4**, 29 (1954).
7. J. von Neumann, "Probabilistic Logics and the Synthesis of Reliable Organisms from Unreliable Components," *Automata Studies, Annals of Mathematics, Study No. 32* (Princeton Univ. Press, Princeton, N.J., 1956).
8. C. E. Shannon and E. F. Moore, *J. Franklin Inst.* **262**, 191, 281 (1956).
9. R. W. Hamming, *Bell System Tech. J.* **29**, 147 (1950).
10. D. Slepian, *ibid.* **35**, 203 (1956).
11. R. C. Bose and D. K. Ray-Chaudhuri, *Information and Control* **3**, 68 (1960).
12. A. Feinstein, *Foundations of Information Theory* (McGraw-Hill, New York, 1958).
13. I. A. Khinchin, *Uspekhi Math. Nauk* **8**, No. 3, 3 (1953) [translated in *Mathematical Foundations of Information Theory* (Dover, New York, 1958)].
14. J. Wolfowitz, *Illinois J. Math.* **1**, 591 (1957).
15. D. Blackwell, L. Breiman, A. J. Thomasian, *Ann. Math. Statistics* **29**, 1209 (1958).
16. B. McMillan, *ibid.* **24**, 196 (1953).
17. N. M. Abramson, *IRE Trans. on Inform. Theory* **IT-5**, 150 (1959).
18. P. Fire, "A Class of Multiple-Error-Correcting Binary Codes for Non-Independent Errors," *Sylvania Rept. No. RSL-E-2* (1959).
19. J. E. Meggitt, *IBM J. Research Develop.* **4**, 329 (1960).
20. D. E. Muller, unpublished work.
21. W. W. Peterson, *Error Correcting and Error Detecting Codes* (Wiley, New York, in press).
22. C. M. Melas, *IBM J. Research Develop.* **4**, 58 (1960).
23. P. Elspas, *IRE Trans. on Circuit Theory* **CT-6**, 45 (1960).
24. P. Elias, *IBM J. Research Develop.* **2**, 346 (1958).
25. G. D. Birkhoff, *Proc. Natl. Acad. Sci. U.S.* **17**, 656 (1931).
26. J. von Neumann, *ibid.* **18**, 70 (1932).
27. A. N. Kolmogorov, *Doklady Akad. Nauk S.S.S.R.* **124**, 754 (1959); see also V. A. Rohlin, *ibid.* **124**, 980 (1959); Y. Sinai, *ibid.* **124**, 768 (1959).
28. Y. V. Linnik, in *Theory of Probability and Its Applications* (1959).
29. I. M. Gelfand and A. M. Yaglom, *Uspekhi Math. Nauk* **12**, No. 1, 3 (1957).
30. L. Apostel and B. Mandelbrot, *Logique, Language et Théorie de l'Information* (Presses Universitaires de France, 1957); B. Mandelbrot, "Role of Sufficiency and of Estimation in the Statistical Structure of Thermodynamics," *IBM Research Rept. No. RC-235* (1960).
31. F. Attneave, *Applications of Information Theory to Psychology* (Holt, New York, 1959).
32. L. Brillouin, *Science and Information Theory* (Academic Press, New York, 1956).
33. S. Kullback, *Information Theory and Statistics* (Wiley, New York, 1959).
34. H. Quastler, *Information Theory and Biology* (Univ. of Illinois Press, Urbana, 1953); *Information Theory in Psychology* (Free Press, Glencoe, Ill., 1956).

Chromosome Cytology and Evolution in Primates

Study of chromosomes adds to our knowledge of evolutionary relationships among primates.

E. H. Y. Chu and M. A Bender

Since the chromosomes of higher organisms are characteristic of a species, they are of obvious value in taxonomic and evolutionary studies. The chromosomes of members of a given species are usually the same in number and form, but those of members of different species are frequently different. Thus the karyotype—the number of chromosomes, their lengths, their relative arm lengths, and other features—is a valuable morphological character, particularly because of its intimate association with the genetic makeup of the species.

Although the evolution of the primates has been a subject of great interest to biologists, it is only relatively recently that any attempt has been made to determine the interrelationships of these animals by comparative studies of their chromosomes. The main reason for this situation has probably been that technical difficulties are involved. Since most mammalian species possess a large number of small chromosomes, counting and observing individual chromosomes are very difficult. The recent development of techniques for the culture of diploid somatic cells, as well as the improvement of cytological procedures, has made it possible to determine not only the chromosome numbers but also the morphology of the chromosomes of a great variety of animals which have not been previously studied. These technical advances led to the discovery by Tjio and Levan (*1*) of the correct chromosome number of man, and stimulated a great many descriptive and experimental studies of mammalian, and especially human, cytogenetics.

The karyotypes of relatively few primates other than man have been deter-

The authors are members of the staff of the Biology Division of Oak Ridge National Laboratory, Oak Ridge, Tenn.

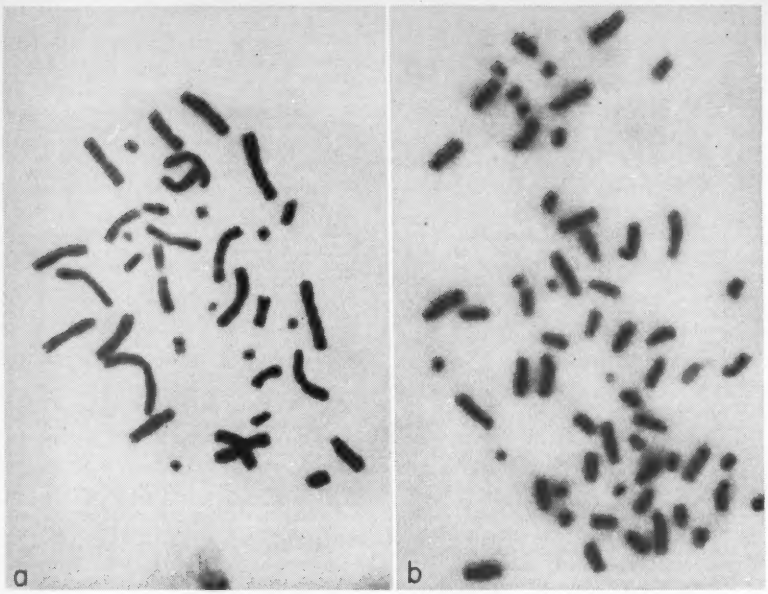


Fig. 1. Chromosomes of cells from tissue–cultured skin biopsies of two species of the genus *Galago*. (*a*) *Galago senegalensis* ♂; (*b*) *Galago crassicaudatus* ♂ (about × 1450).

mined by the modern cytological techniques now available (*2–5*). The need for additional studies is apparent, especially since many primate species are diminishing in number and are in danger of becoming extinct.

For a systematic survey of karyotypes in primates, it has been found feasible to utilize small pieces of tissues, derived either by biopsy or necropsy from captive animals, for in vitro cultivation and cytological examination. Successful cell cultures have been established even after the tissue specimens have been transported over long distances, a factor which involved considerable delay before culturing.

In the present article (*6*) we review the available information on the chromosome cytology of the order Primates. In addition, some recent data on the karyotypes of several species of primates are presented. These studies have revealed a notable variation, in both chromosome number and morphology, among all groups of primates so far examined. Detailed karyotypic comparisons also suggest some possible mechanisms of chromosome evolution. Comparative cytological studies make at least certain conclusions about species relationships possible; the use of criteria other than gross morphological or anatomical characters serves to supplement the present taxonomic evidence.

Most taxonomists agree that the order Primates may be divided into three major subgroups. The first, the Prosimiae, includes all the nonsimian primates, such as lemurs, lorises, tarsiers, and the tree shrews. The simian primates fall into two groups: the Platyrrhina or New World monkeys, and the Catarrhina, which include the Old World monkeys, anthropoid apes, and man. We consider each subgroup separately.

Prosimiae

Of prosimian primates, only five genera (six species) have been studied cytologically (Table 1). Of the Tupaiidae, only one specimen of *Urogale everetti* (Philippine tree shrew) has been examined. Dodson (*7*) has made tentative counts on cells from testis and corneal epithelium and has found that the diploid chromosome number ($2n$) is 26.

Lemur macaco (the black lemur) represents the only species of Lemuriformes that has been examined. Somatic cells grown in culture from skin of a young male and an adult female animal were used for chromosome analysis. The diploid chromosome number is 44. The chromosome complement is readily classified into two separate size-groups. All but one of the 11 pairs of macrochromosomes, ranging from 3 to 8 μ in length, are metacentric or submetacentric; the shortest macrochromosome pair is acrocentric. All the ten microchromosome pairs, ranging from 0.8 to 1.2 μ in length, are acrocentric. The X chromosome is about 5 μ long with a terminal centromere. The Y chromosome is the smallest, and it is acrocentric.

In many cases the chromosome arm indices of each individual chromosome were calculated, by the system of Tjio and Levan (*1*). The chromosomes are classified arbitrarily into three groups: M chromosomes (median-submedian centromeres), S chromosomes (subterminal centromeres), and A chromosomes (acrocentric, with nearly terminal centromeres). Thus, in *Lemur macaco*, there are 12 M chromosomes, 8 S chromosomes, and 22 A chromosomes. Both the X and Y chromosomes are of the A type. It should be pointed out, however, that because of variability in arm length it is sometimes difficult to assign a particular chromosome pair to a particular class. We have attempted to assign the chromosomes of most of the species studied, but have indicated some of the uncertain cases by placing the numbers in brackets in the tables. Also, in a number of instances, such as *Nycticebus* and *Perodicticus*, the quality of the cytological preparations, while permitting counting, did not lend itself to karyotype analysis.

In the Lorisiformes, two genera (one species each) of the family Lorisidae have been studied. The diploid chromosome number of *Nycticebus coucang* (slow loris) is 50 (*2*); that of *Perodicticus potto* is 62.

Of the family Galagidae, two species of *Galago* (the bush babies) have recently been examined. The diploid chromosome number of *Galago senegalensis* is 38, confirming an earlier finding, reported by Matthey (*8*), who had studied its chromosomes in spermatogenesis. The chromosome morphology, as illustrated in Fig. 1*a*, agrees with Matthey's results. Both macro- and microchromosome types are present in this species. Most of the macrochromosomes have either median or submedian centromeres. However, two pairs of microchromosomes also have median centromeres. The X chromosome is a medium-sized (6 μ in length) subtelocentric; the Y is acrocentric, and it is the smallest element in the complement (1 μ in length).

Most interesting is the karyotype of *G. crassicaudatus*, as shown in Fig. 1*b*.

The diploid chromosome number is 62. In both chromosome number and morphology, this species is strikingly different from *G. senegalensis*. In *G. crassicaudatus*, the chromosomes are in general shorter than the macrochromosomes of *G. senegalensis*. There seems to be no discontinuity in the range of chromosome lengths. The chromosomes of the longest pair are about 3.5 μ long, and the shortest, the Y chromosome, is 0.8 to 1 μ long. Most of the chromosomes have nearly terminal centromeres, with the exception of three pairs which clearly possess subterminal centromeres. The X chromosome is subterminal and approximately 2 μ long.

Despite the obvious karyotypic differences between *G. senegalensis* and *G. crassicaudatus*, detailed karyotypic comparisons reveal interesting relationships. First, the total metaphase chromosome lengths of these two species are approximately equal. Second, there is close agreement in the number and length of chromosome arms between the two species.

Table 1. Mitotic chromosome numbers and types of prosimian primates. The classification used in this and the following tables is that of Fiedler (*35*). Numbers in brackets are tentative. M, metacentric; S, subterminal; A, acrocentric.

Scientific and common name	No. of individuals examined		Chromosomes						Reference citation
	Male	Female	2*n*	M	S	A	X	Y	
Family **Tupaiidae**									
Urogale everetti—Philippine tree shrew	1		[26]						(*7*)
Family **Lemuridae**									
Lemur macaco—Black lemur	1	1	44	12	8	22	A	A	*
Family **Lorisidae**									
Nycticebus coucang—Slow loris		1	50						(*2*)
Perodicticus potto—Potto		1	62						*
Family **Galagidae**									
Galago senegalensis—Lesser bush baby	1		38				S	S	(*8*)
	2	2	38	20	10	6	S	A	*
Galago crassicaudatus—Grand or thick-tailed bush baby	2	2	62	0	6	54	S	A	*

* Data of Chu and Bender, this report.

Platyrrhina

Prior to 1958, only one count was available for the Platyrrhina. Painter (*9*) reported that a specimen of an unknown species of the ringtail, *Cebus*, had a diploid chromosome number of 54. To date, karyotypic analyses have been made of four genera of the family Cebidae (*2*), of two genera of the family Callithricidae, and of the unique genus *Callimico* (Goeldi's marmoset) (*3*). In addition, tentative counts have been made on single specimens of four additional genera of Cebidae (*10*).

In contrast to the prosimian *Galago* and the catarrhine *Cercopithecus*, no difference in number has been found between species of the same genus in the Platyrrhina. A summary of chromosome numbers and karyological characteristics of platyrrhine primates is presented in Table 2.

In the family Cebidae, a wide range in chromosome number has been encountered. Forty-six is the commonest diploid number. In the four genera for which detailed karyotype analyses have been made, a wide variation in the number of acrocentric chromosomes is found. Thus, *Cebus* has 13 acrocentric pairs, while *Ateles* (spider monkey) has only one. *Ateles* has one pair of chromosomes with a fairly prominent secondary constriction, and *Saimiri* (squirrel monkey) also has one pair with a constriction. Neither *Cebus* nor *Callicebus* (titi) has a constricted pair. This is in contrast to the situation in the Catarrhina, which are discussed in the next section. The presence of a smallest, acrocentric autosomal pair is a constant feature of the cebid karyotype, as is the presence of a next-to-smallest metacentric pair. The Y chromosome of all the Cebidae studied appears to be acrocentric and is the smallest chromosome in the complement. The X chromosome, on the other hand, varies; it ranges from acrocentric (*Cebus*) to metacentric (*Ateles*). One specimen of *Ateles* differed slightly in karyotype from the others (*11*). One member of the smallest, acrocentric pair in this animal possessed a small second arm, possibly the result of an inversion. In vivo studies of the bone marrow of this specimen established that the aberration was present in the animal and did not arise during the culture of cells for cytological examination.

In the family Callithricidae, the karyotypes of *Callithrix* (marmoset) and *Leontocebus* (tamarin) are virtually identical. The karyotype of *Callimico* is markedly different from that of the marmoset, even though the chromosome numbers differ only by 2. Of particular interest is the fact that *Callimico* has eight pairs of acrocentric chromosomes, whereas the marmosets have only five. None of the three genera possesses a pair with secondary constrictions. The Y chromosome of the marmosets is remarkable, since it is apparently meta-

Table 2. Mitotic chromosome numbers and types of platyrrhine primates. Numbers and letters in brackets are tentative.

Scientific and common name	No. of individuals examined		Chromosomes						Reference citation
	Male	Female	2*n*	M	S	A	X	Y	
Family **Cebidae**									
Ateles geoffroyi—Hooded spider monkey	1		34	12	18	2	M	A	(*2*)
Ateles paniscus chamek—Black-faced spider monkey	1	1	34	12	18	2	M	A	(*2*)
Ateles belzebuth—Golden spider monkey	5	6	34	12	18	2*	M	A	†
Saimiri sciureus—Squirrel monkey	1	2	44	16	14	12	S	A	(*2*)
Callicebus cupreus—Red titi	1		46	10	10	24	[S	A]	(*2*)
Cebus sp.—Ringtail	1		54				S	A	(*9*)
Cebus apella—Cinnamon ringtail	2		54	6	20	26	A	A	(*2*)
	2		54						†
Cebus capucinus—Capuchin ringtail		1	54	6	20	26	[A]		(*2*)
	2		54						†
Alouatta seniculus—Red howler	1		[44]						‡
Aotes trivirgatus—Owl monkey	1		[54]						‡
Cacajao rubicundus—Uakari	1		[46]						‡
Pithecia pithecia—Saki		1	[46]						‡
Callimico goeldii—Goeldi's marmoset		1	48	2	30	16			(*3*)
Family **Callithricidae**									
Callithrix chrysoleucos—Golden or silky marmoset	1	2	46	4	30	10	S	M	(*3*)
Leontocebus illigeri—Red-mantled tamarin	2	2	46	4	30	10	S	M	(*3*)

* In one animal, there was one metacentric and one acrocentric, instead of a pair of acrocentrics (see text).
† Data of Chu and Bender, this report. ‡ Data of Bender and Mettler, unpublished.

centric, which is in contrast to the other Platyrrhina studied. It is unfortunate that the only specimen of *Callimico* studied was a female, as it is obviously quite important to determine the form of the Y chromosome in this species.

Catarrhina

In Table 3, the chromosome numbers and karyological characteristics of Old World primates, including five genera (17 species) in the subfamily Cercopithecinae (*Macaca, Papio, Cercocebus, Erythrocebus,* and *Cercopithecus*) and one in the subfamily Colobinae (*Presbytis*) of the family Cercopithecidae, as well as one each of the families Hylobatidae and Pongidae, are listed. Most notable is the variation in chromosome number among various genera, and even within a single genus, *Cercopithecus*. Diploid chromosome numbers of 42, 44, 48, 50, 54, 60, 66, and 72 have been found in the Catarrhina.

The chromosomes of all the species in the subfamily Cercopithecinae have a number of morphological characteristics in common. First, sex-chromosome dimorphism (an X and a Y) has been found in all species. The X chromosomes are generally of medium size, with submedian centromeres. The submetacentric Y chromosome is the smallest element in each complement; it is smaller than the human Y (*4, 12*). Second, there is a single autosomal pair having a marked secondary constriction, which may carry nucleolus organizers, in each species. They are all morphologically alike in the sense that their secondary constrictions are of similar lengths and are located close to the centromere. However, the total length of this particular chromosome pair appears to differ in different species (*4*). Third, with the exception of *Erythrocebus* and *Cercopithecus*, there are no truly acrocentric autosomes in this family.

The most detailed description of primate chromosome morphology (exclusive of human chromosomes) is probably that of the rhesus monkey (*Macaca mulatta*) by Rothfels and Siminovitch (*13*). Painter (*14*) had reported a diploid chromosome number of 48 for this species; but Shiwago (*15*) counted 42, and this number was later confirmed by several workers (*4, 12, 13*). According to Rothfels and Siminovitch (*13*), the Y chromosome is the smallest element in the complement and is acrocentric; Chu and Giles (*4*), however, found that it was metacentric. The X chromosome ranks eighth in decreasing order of size and typically has an arm ratio of 1.4. The autosomes form a graded size series of metacentric chromosomes, 3 to 15 μ long in early metaphase, and with arm ratios from 1.1 to 3.3. On the basis of relative length, arm ratio, and occurrence of secondary constrictions, most chromosomes of the complement can be individually identified.

The karyotype of *Macaca irus* is probably identical with that of *M. mulatta*. The same diploid number of 42 has been reported for both *M. nemestrina* (*12*) and *M. cyclopis* (*16*).

Among the baboons, *Papio papio* and *P. doguera* were found to have the same karyotype. Although the diploid chromosome number is the same as in *Macaca*, the chromosomes in general are shorter in length and the karyotypes differ in relative numbers of M and S chromosomes (Table 3).

Three species of *Cercocebus* (mangabeys) have been examined so far. The karyotype of *C. torquatus* differs from those of *Macaca* and *Papio*. Tentative counts on *Cercocebus albigena* and *C. galeritus* indicate the same chromosome number, 42 (*17*).

The diploid chromosome number of *Erythrocebus patas* (patas monkey) is 54. It has 18 M and 24 S chromosomes, and 10 A chromosomes. Three different diploid numbers, 60, 66, and 72, have been found in the single genus *Cercopithecus* (guenons). It is particularly interesting to note that there are

Table 3. Mitotic chromosome numbers and types of catarrhine primates. Numbers and letters in brackets are tentative.

Scientific and common name	No. of individuals examined		Chromosomes						Reference citation
	Male	Female	2*n*	M	S	A	X	Y	
Family Cercopithecidae									
Macaca mulatta—Rhesus monkey	2	2	48				A	A	(*14*)
	2		42						(*15*)
	1		42						(*12*)
	3	1	42	18	22	0	M	M	(*4*)
	Not stated		42	18	22	0	M	A	(*13*)
Macaca irus—Cynomolgus or crab-eating macaque	1		42	[18	22]	0	[M	M]	*
Macaca nemestrina—Pig-tailed macaque	1		42						(*12*)
Macaca cyclopis—Formosan macaque	1		42						(*16*)
Papio papio—Guinea baboon	1		42						(*12*)
		1	42	[30	10]	0			(*4*)
Papio doguera—Olive baboon	2		42	[30	10]	0	S	M	(*4*)
Papio sphinx—Mandrill	1		42			0			(*2*)
Cercocebus torquatus lunulatus—White-crowned mangabey	2		42	[14	26]	0	S	M	(*4*)
Cercocebus torquatus torquatus—Sooty mangabey	1		42			0			(*2*)
Cercocebus albigena—Grey-cheeked mangabey	1		[42]						(*17*)
Cercocebus galeritus—Crested mangabey	1		[42]						(*17*)
Erythrocebus patas—Patas monkey	1	3	54	[18	24]	10	S	M	(*4*)
Cercopithecus aethiops sabaeus—African green monkey	1		60	[18	34]	6	M	M	(*4*)
Cercopithecus aethiops tantalus—African white monkey	2	1	60	[18	34]	6	M	M	(*4*)
Cercopithecus diana roloway—Diana monkey	1	1	60			6			(*4*)
Cercopithecus neglectus—De Brassa's guenon	1		[60]						(*17*)
Cercopithecus mona Campbelli—Campbell's guenon		2	66			12			(*4*)
Cercopithecus mona mona—Mona guenon	1	1	66			[6]			(*2*)
Cercopithecus mona (denti)—Guenon	1		[66]						(*17*)
Cercopithecus nictitans buttikoferi—White-nosed or spot-nosed guenon		3	66	[28	24]	12			(*4*)
Cercopithecus l'Hoesti—l'Hoest's guenon		1	72	[28	24]	18			*
Presbytis entellus—Langur	1		50				M	A	(*16*)
Family Hylobatidae									
Hylobates hoolock—Hoolock gibbon		1	44	38	6	0			*
Family Pongidae									
Pan troglodytes—Northern chimpanzee	1		[48]						(*18*)
		5	48	38	10	0			†
	7	2	48				[M	M]	(*5*)
Family Hominidae									
Homo sapiens—Man	over 200		46	16	18	10	M[S]A		(*20*)

* Data of Chu and Bender, this report. † Data of Bender and Mettler, unpublished.

three pairs of acrocentric chromosomes in the 60-chromosome species, six pairs in the 66-chromosome species, and nine pairs in the 72-chromosome species.

There is only one count for a species of the subfamily Colobinae. Makino (*16*) has reported that the diploid chromosome number of *Presbytis entellus* (langur) is 50. The X chromosome is described as submetacentric and the Y as acrocentric.

The cytology of surprisingly few anthropoid apes is known. The karyotypes of one species of gibbon, *Hylobates hoolock*, has been recently investigated by cell-culture techniques with skin and kidney biopsies. The chromosomes of a kidney cell from *H. hoolock* are shown in Fig. 2. The diploid chromosome number is 44. There are 38 M, 6 S, and no A chromosomes. A single pair of chromosomes with conspicuous secondary constrictions, similar in morphology to those in Cercopithecidae, could be easily recognized.

The chromosome number of *Pan troglodytes* (chimpanzee) was investigated by Yeager *et al.* (*18*), who made a tentative count of $2n = 48$ from the spermatogonia of one specimen. This has recently been confirmed by Young *et al.* (*5*) and by Bender and Mettler (*19*). The female karyotype consists of 19 pairs of M chromosomes, 5 pairs of S chromosomes, and no A chromosomes. The X is a moderately large metacentric chromosome, and the Y is probably a very small metacentric chromosome (*5, 19*).

The diploid chromosome number of man is 46. There are five pairs of acrocentric chromosomes. The X is submetacentric and ranks about sixth in decreasing order of size. The Y is one of the smallest chromosomes, and it is acrocentric (*20*).

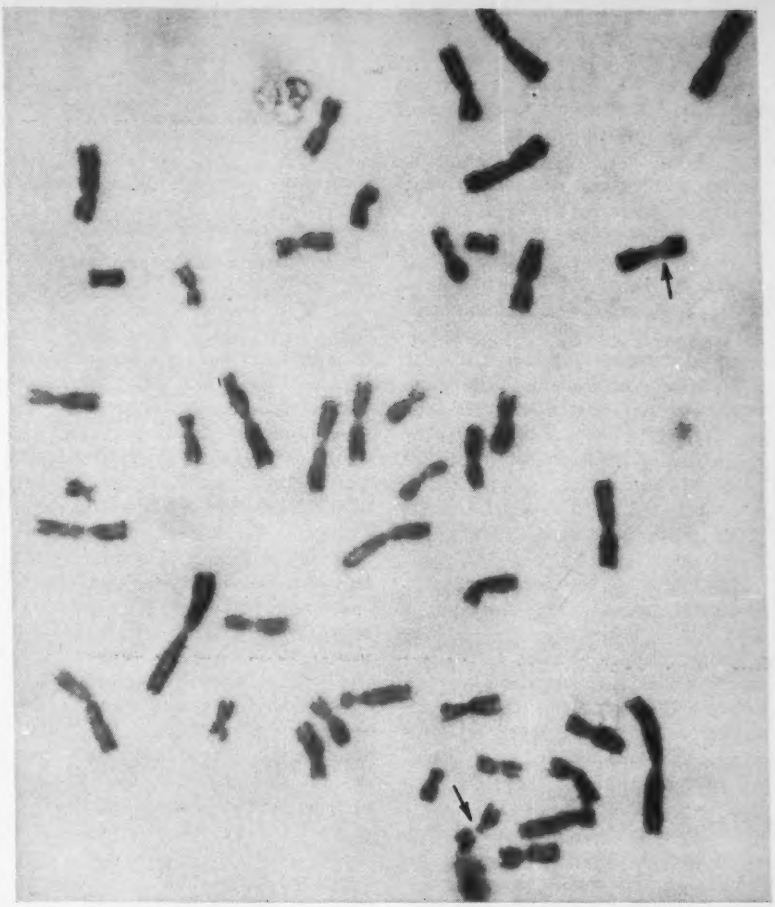


Fig. 2. The chromosomes of a tissue-cultured cell from the kidney of a *Hylobates hoolock* ♀. Arrows indicate the positions of secondary constrictions (about × 2100).

Discussion

This survey of primate chromosome cytology is an attempt to summarize available information, thus bringing up to date the earlier tabulations by Tobias (*21*) and Chiarelli (*22*). Classical studies and recent findings on human cytology have not been included since the subject has been well discussed elsewhere (see *23*). However, a detailed karyotypic comparison between man and other primates, especially the anthropoid apes, should prove to be of particular interest.

The cytological results here summarized have indicated that the use of tissue culture, coupled with the application of suitable modern cytological techniques, can provide useful information on chromosome number and morphology in various species of primates. It should be emphasized, however, that meiotic chromosomes remain important as sources for comparison and verification. Furthermore, for a definitive establishment of chromosome homology between species the meiotic chromosome behavior in accidental and experimental interspecific hybrids must be studied.

These studies indicate a great diversity in chromosome number and morphology among representatives of the three major groups of the order Primates. The numbers range from $2n = 34$ to $2n = 72$, and in such a way that their only common denominator is 2. In the subfamily Cercopithecinae of the family Cercopithecidae, the fact that the numbers of all five genera are multiples of 6 leads to a consideration of polyploidy as a possible evolutionary mechanism. However, several lines of evidence have been presented (*4*) for believing this interpretation to be improbable. One objection is that polyploidy will create difficulties in the sex-determination mechanisms in mammals. Another is that in each species there is only one pair of chromosomes having a clear secondary constriction. Also, the total chromosome length, with the possible exception of the genus *Papio*, is about the same. Finally, spectrophotometric measurements (*24*) of Feulgen-stained nuclei of three representative species (*Macaca mulatta*, $2n = 42$; *Erythrocebus patas*, $2n = 54$; *Cercopithecus aethiops*, $2n = 60$) show that despite differences in chromosome number the diploid deoxyribonucleic acid values are essentially identical.

It appears more likely that in the pri-

mates differences in chromosome number have arisen from alterations in the chromosomes of a basic set, giving either larger numbers of chromosomes or, more probably, smaller numbers of chromosomes with little loss or gain of chromosomal material.

Patterson and Stone (*25*) have suggested for the genus *Drosophila*, where the most primitive species have rod-shaped chromosomes, that centric fusions account for the reduction in chromosome number and the origin of metacentric and subterminal chromosomes. Makino (*26*) showed that the chromosome number of the domestic sheep is 54, consisting of 48 acrocentrics and 6 metacentrics. He found that the goat, on the other hand, has 60 acrocentric chromosomes. Makino suggested that 12 of the chromosomes of the goat correspond to the six metacentrics of the sheep. Such a pattern of fusion has been found in grasshoppers (*27*), snails (*28*), shrews (*29*), the rodent subfamily Microtinae (*30*), and gerbils (*31*).

The karyotypes of many of the primates studied demonstrate a marked correlation between low chromosome number and a low number of acrocentric chromosomes, and, conversely, a frequent correlation between high chromosome numbers and a large number of acrocentrics. As has been pointed out before by Matthey (*8*) and by Bender and Mettler (*2*), these correlations suggest that a Robertsonian type of chromosome evolution, by means of centric fusion, may also have played an important role in the primates. Thus, in the genus *Galago*, *G. senegalensis*, with only 38 chromosomes, has only three pairs of acrocentrics, while *G. crassicaudatus*, which has 62 chromosomes, has 27 pairs of acrocentrics. In the genus *Cercopithecus*, where three different chromosome numbers occur, those species with 60 chromosomes have six acrocentrics, those with 66 chromosomes have six pairs, and the one species with 72 chromosomes has nine pairs. In this case, the numbers of acrocentrics suggest that centric fusion can account quantitatively for the difference in chromosome number.

In the Platyrrhina, where thus far no differences in number between species of the same genus have been reported, we again see a suggestion that centric fusion may have been an important evolutionary mechanism. In the Cebidae, a rough correlation between chromosome number and degree of specialization is evident; *Cebus* is certainly a fairly generalized animal, while *Ateles* is quite specialized for a brachiating existence. *Cebus*, with $2n = 54$, has 13 pairs of acrocentrics (not counting the sex chromosomes), while *Ateles*, with $2n = 34$, has only one. The genera with intermediate chromosome numbers have intermediate numbers of acrocentrics.

Table 4. Mean chromosome number (± standard deviation) and *nombre fondamental* of the three subgroups of primates.

Subgroup	Mean diploid chromosome number	Approximate *nombre fondamental* (N.F.)
Prosimiae (6 species)	47.0 ± 14.1	62–70
Platyrrhina (11 genera)	46.2 ± 5.3	66–82
Catarrhina (21 species)	49.8 ± 10.0	84–132

It may be argued, of course, that the same correlations between chromosome number and number of acrocentrics could theoretically be caused by either centric *fusion* or centric *fission*. There are, however, several arguments against the centric fission mechanism. While the loss of a centromere, through fusion, can come about by a simple translocation, gain of a centromere requires an apparently less frequent mechanism, such as centrometric misdivision or, possibly, trisomy. Furthermore, more specialized forms must, as a general rule, have evolved from less specialized ancestral forms. And there may be a selective advantage for a specialized form in having fewer chromosomes, since this may lead to the creation of blocks of genes which are less likely to reassort at meiosis, and hence to a greater probability that offspring will be sufficiently like the parents to survive in the narrow ecological niche to which they are adapted. It is interesting to note that centric fusion has occurred in at least one case in man without any obvious phenotypic alteration (*32*).

The lack of an exact correlation between chromosome number and number of acrocentrics in the primates does not, of course, argue against the fusion mechanism. Fusion may occur not only in such a way as to yield a metacentric (centric fusion) but it may also occur in such a way as to yield a longer acrocentric (by tandem fusion). Tandem fusions may also yield larger subterminals from metacentrics and acrocentrics. In addition, pericentric inversions which occur after centric fusion may convert metacentrics into acrocentric or subterminal chromosomes. It is clear that such events may have occurred in the evolution of groups, like most of the Cercopithecidae, where there are no acrocentric chromosomes, and in animals, such as *Saimiri*, which have very long chromosomes.

Matthey (*33*) has calculated the average chromosome number for a large number of mammalian species. He found that the mean diploid number was close to 47, with a standard deviation of about 11. For seven primate species, including man (at $2n = 48$), Matthey found the mean to be 47.4, and the standard deviation to be about 4.5 (*8*). We have calculated these values for all of the primate species available to us. Our calculations have been made on a per species basis, except for the Platyrrhina, where we have used the number for each genus since no variation between species has been found. Table 4 presents the mean diploid chromosome number and the number of major chromosome arms of the subgroups of primates. It can be seen that our values do not differ significantly from those of Matthey.

As pointed out by Matthey (*34*), the number of major chromosome arms (the *Nombre Fondamental*, or N.F.) is just as significant in the study of chromosome evolution as the mean number of chromosomes. The range of N.F. for the species in each subgroup for which such determinations can be made is also presented in Table 4. The ranges for the Prosimiae and the Platyrrhina are similar to those reported by Matthey (*8*) for four primate species, but the range for the Catarrhina is much greater.

Finally, the small amount of work that has been done so far already suggests that karyotype analysis can be of use to the primate taxonomist. The marmosets are a case in point. While Fiedler (*35*) places the marmosets and tamarins in only two separate genera, other taxonomists believe that the family Callithricidae is composed of many genera. The absence of any karyotypic difference between *Leontocebus* and *Callithrix* lends weight to Fiedler's view of a lower number of genera, although more species of each genus must be examined before any final conclusion can be drawn. Unfortunately, there are also cases where karyotypic analysis has not been very helpful. As an example, we may cite the case of *Callimico*. This genus has been placed both in the Callithricidae and in the Cebidae; it has even been proposed that it should oc-

cupy a separate family of its own. The karyotype of *Callimico* is intermediate between the marmoset karyotype and that of the cebid genus *Callicebus*. It can only be said that in this case the chromosomal evidence is in agreement with the idea, expressed by Hill (*36*), that the Callithricidae are a specialized, rather than a primitive group, and that *Callimico* is more primitive (and unspecialized) and is hence probably closer to the ancestral cebid stem.

References and Notes

1. J. H. Tjio and A. Levan, *Hereditas* **42**, 1 (1956).
2. M. A Bender and L. E. Mettler, *Science* **128**, 186 (1958).
3. ———, *Cytologia*, in press.
4. E. H. Y. Chu and N. H. Giles, *Am. Naturalist* **91**, 273 (1957).
5. W. J. Young, T. Merz, M. A. Ferguson-Smith, A. W. Johnston, *Science* **131**, 1672 (1960).
6. This article is based on two papers presented at a symposium on the evolutionary and experimental biology of the primates held during the 29th annual meeting of the American Association of Physical Anthropologists, 12–14 May 1960, Washington, D.C. The specimens of *Lemur, Galago*, and *Hylobates hoolock* were obtained through the support of a National Science Foundation grant (G-12331) to Dr. J. Buettner-Janusch, Yale University. Oak Ridge National Laboratory is operated by Union Carbide Corporation for the United States Atomic Energy Commission.
7. E. O. Dodson, personal communication.
8. R. Matthey, *Rev. suisse zool.* **62**, suppl., 190 (1955).
9. T. S. Painter, *Science* **56**, 286 (1922).
10. M. A Bender and L. E. Mettler, unpublished data.
11. M. A Bender, in *Immediate and Low Level Effects of Ionizing Radiations*, A. A. Buzzati-Traverso, Ed. (Taylor and Francis, London, 1960), pp 103–118. (Proceedings of a symposium held 22–26 June 1959 in Venice, Italy, published as a supplement to *Intern. J. Radiation Biol.*)
12. C. D. Darlington and A. Haque, *Nature* **175**, 32 (1955).
13. K. H. Rothfels and L. Siminovitch, *Chromosoma* **9**, 163 (1958).
14. T. S. Painter, *J. Exptl. Zool.* **39**, 433 (1924).
15. P. I. Shiwago, *Bull. biol. méd. exptl. U.R.S.S.* **8**, 3 (1939).
16. S. Makino, *Cytologia* **16**, 288 (1952).
17. N. Tappen, personal communication.
18. C. H. Yeager, T. S. Painter, R. M. Yerkes, *Science* **91**, 74 (1940).
19. M. A Bender and L. E. Mettler, unpublished data.
20. J. A. Böök *et al.*, *Lancet* **1**, 1063 (1960).
21. P. V. Tobias, in *Chromosomes, Sex Cells, and Evolution in a Mammal; Based Mainly on Studies of the Reproductive Glands of the Gerbil, and a New List of Chromosomes of Mammals* (Lund, Humphries, London, 1956).
22. B. Chiarelli, *Caryologia* **11**, 99 (1958).
23. E. H. Y. Chu, *Am. J. Human Genet.* **12**, 97 (1960); C. E. Ford, *ibid.* **12**, 104 (1960); C. Stern, *ibid.* **11** (No. 2, pt. 2), 301 (1959).
24. R. Kleinfeld and E. H. Y. Chu, *Cytologia* **23**, 452 (1958).
25. J. T. Patterson and W. S. Stone, in *Evolution in the Genus* Drosophila (Macmillan, New York, 1952).
26. S. Makino, *Cytologia* **13**, 39 (1943).
27. M. J. D. White, in *Animal Cytology and Evolution* (Cambridge Univ. Press, New York, ed. 2, 1954).
28. H. Staiger, *Chromosoma* **6**, 419 (1954).
29. C. E. Ford, J. L. Hamerton, G. B. Sharman, *Nature* **180**, 392 (1957).
30. R. Matthey, *Rev. suisse zool.* **64**, 39 (1957).
31. J. Wahrman and A. Zahavi, *Proc. Intern. Congr. Genet. 10th Congr.* **2**, 304 (1958).
32. P. S. Moorhead, W. J. Mellman, D. M. Batipps, *Genetics* **45**, 1001 (1960).
33. R. Matthey, *Rev. suisse zool.* **62**, 163 (1955).
34. ———, *Caryologia* **6**, 1 (1954).
35. W. Fiedler, *Primatologia* **1**, 1 (1956).
36. W. C. O. Hill, *Trans. Am. Phil. Soc.* **49** (n.s.), pt. 5 (1959).

Human Behavior during the Tsunami of May 1960

Research on the Hawaiian disaster explores the consequences of an ambiguous warning system.

Roy Lachman, Maurice Tatsuoka, William J. Bonk

At 1:05 HST on the morning of 23 May 1960, a great sea wave, or tsunami, caused by an earthquake off the coast of Chile (*1*), hit the Hawaiian city of Hilo. Despite at least 10 hours of warning, the wave killed 61 persons, injured several hundred more, and completely destroyed an estimated 500 dwellings.

A study group was organized by the Hawaii Division of the Hawaiian Academy of Science to objectively examine the human element in the disaster (*2*). The objectives of the research, subsequently undertaken, were to study the subjective interpretations of the warnings and the resulting behavior.

A questionnaire was prepared, to be administered to a cross section of the adult population of the affected areas. The questionnaire was designed on the basis of preliminary observations conducted in the devastated area and of impressions recorded prior to the impact. Pre-testing of the survey instrument was precluded by limitations of time and resources. The prepared questionnaire was explained to the interviewers in an item-by-item discussion of the intent of each question.

Many of the interviewers were close acquaintances of the individuals they were to interview. Hence, open and frank discussions could be initiated almost at once. Also, since the majority of affected families had not evacuated, failure to evacuate carried no social stigma. There is reason to believe, therefore, that the responses made by the people interviewed give a truthful picture of their impressions of the events.

A large number of those interviewed were at the Red Cross disaster shelter. This group formed a readily available starting point for interviews and also provided leads for locating other displaced individuals. Various church organizations made available the new addresses of their displaced congregations. The Department of Public Instruction required students in displaced families to report their new addresses. Lists of victims were thus compiled, and those to be interviewed were selected in a nonsystematic fashion. The interviewing was conducted over a period of seven successive days.

Representativeness of the Sample

The conditions under which the survey was made precluded our drawing a pure random or stratified random sample. No one possessed an exhaustive list of tsunami victims. Neither did we have valid information on the geographic distribution, or other relevant characteristics, of our population before the impact. We therefore sought to achieve, through the means described above, a "quasi-random" sample that

Dr. Lachman is research psychologist at the Johns Hopkins Hospital and School of Medicine, Baltimore, Md. Dr. Tatsuoka and Mr. Bonk are assistant professor of mathematics and science and instructor in anthropology-sociology, respectively, at the University of Hawaii, Hilo.

Table 1. Composition of sample.

Sex	Age	Race	Education	Total sample		Nonevacuees		Evacuees	
				N	%	*N*	%	*N*	%
Male				140	42.8	88	44.7	52	40.0
Female				187	57.2	109	55.3	78	60.0
	18–27			59	18.0	29	14.7	30	23.1
	28–37			76	23.2	41	20.8	35	26.9
	38–47			77	23.5	45	22.8	32	24.6
	48–57			64	19.6	45	22.8	19	14.6
	58–67			33	10.1	25	12.7	8	6.2
	68 or older			18	5.5	12	6.1	6	4.6
		Caucasian		8	2.4	3	1.5	5	3.8
		Filipino		33	10.1	23	11.7	10	7.7
		Hawaiian		74	22.6	23	11.7	51	39.2
		Japanese		178	54.4	123	62.4	55	42.3
		Portuguese		15	4.6	14	7.1	1	0.8
		Other		19	5.7	11	5.5	8	6.1
			Grade or intermediate school	151	46.2	100	50.8	51	39.1
			High school	152	46.4	81	41.1	71	54.6
			College	24	7.3	16	8.1	8	6.2

is fairly representative of the population. We can, at the very least, assert that there was no artificial factor operating in the selection of our sample.

One factor lends support to our belief that findings in our sample of 327 can safely be generalized to the immediate parent population. The Red Cross records 500 families who registered or applied for assistance. This allows us to estimate the size of the total affected *adult* population at something between 1000 and 1200. Our sample of 327, then, represents between one-fourth and one-third of the entire adult population displaced by the tsunami. Samples of this order of relative magnitude, in the selection of which no artificial factors are involved, can, in general, be regarded as sufficiently representative to enable investigators to draw valid conclusions for the immediate parent population.

To evaluate the generalizability of our findings to future populations in Hawaii or to populations of disaster victims in the United States as a whole, cross validation through subsequent studies would be necessary, no matter how adequate a random sample we had been able to select from the target population.

In presenting the findings of our survey, we give, first, a description of various characteristics of the total sample. This is followed by the survey data, presented in the chronological order of the disaster events: pre-impact period, impact period, and post-impact period. Findings for the pre-impact period are divided into data on response to the siren signal and data in response to other warnings. We conclude with a consideration of the possible determinants of adaptive behavior during the emergency.

Characteristics of the Sample

The composition of our sample of 327 individuals in terms of sex, age, race, and education is summarized in Table 1. Our sample included 28 persons who had lost one or more members of their immediate family in the disaster. Also, 50 persons in the sample (15 percent of those interviewed) had themselves suffered injuries. Of these 50 people, 47 had not left their homes; the three injured among the evacuees either (i) left but later returned to their homes or (ii) sought safety in an area which was itself stricken.

Pre-Impact Period

The siren signal. The tidal-wave warning siren sounded for a 20-minute period more than four hours prior to the impact of the wave, yet only 40 percent of our sample evacuated, and presumably this was the percentage of the entire population of the devastated areas that evacuated. Therefore, the question was posed, "Did you hear the 8:30 siren on Sunday, May 22?" Of those interviewed, 309 (95 percent) replied that they had heard the siren; 18 (5 percent) replied that they had not. Of those who heard the siren, 127 (41 percent) evacuated and 182 (59 percent) did not.

The 309 individuals who had heard the siren were further asked if they knew what it meant. Only 18 individuals (6 percent) said they did not. However, in the course of analyzing our data it became obvious that not all of the 291 persons who said they knew what the siren meant had the same understanding of its significance. More revealing than the "yes" or "no" reply to this question, therefore, were the answers to the next two questions ("What did you do upon hearing the siren, and why?"), from which we could (in most cases) infer what the siren meant to each individual. In addition, unsolicited comments as to the meaning of the siren were frequently available. In Table 2 are summarized the various meanings the siren had for the 291 individuals who heard it.

Since the siren meant so many different things to different people, we began to wonder just what it was meant to signify officially. Consulting the telephone directory, which is presumably the official medium for disseminating this information, we found that the siren signal was characterized as an "alert," with no indication as to what behavioral response was expected of the public upon hearing it. It is significant that, of the 84 persons who we infer took the siren to mean an "evacuation signal," 74 (88 percent) did indeed evacuate their homes—if not right away, at least prior to the impact of the wave.

The distribution of responses to the

Table 2. Various meanings of the siren for the individuals interviewed who heard it.

Interpretation	Total sample		Nonevacuees		Evacuees	
	N	%	*N*	%	*N*	%
Alert	14	4.8	10	5.9	4	3.3
Warning	13	4.5	8	4.7	5	4.1
Preliminary signal preceding evacuation signal	71	24.4	55	32.4	16	13.2
Evacuation signal	84	28.9	10	5.9	74	61.2
Signal to await further information	26	8.9	24	14.1	2	1.7
Signal to make preparations	18	6.2	12	7.1	6	5.0
Subjective meaning not ascertainable	65	22.3	51	30.0	14	11.6
Total	291	100.0	170	100.1	121	100.1

siren is shown in Table 3. The disaster victims are classified according to their immediate response to the siren—according to whether they continued their normal routine, evacuated, or waited for information and instructions.

The "do-nothing" group consisted of 44 individuals who disregarded the siren signal and continued their normal routine. Most of these individuals (29, or 66 percent) stated that they believed themselves to be in a safe area. The remaining individuals in this group were either in the movies, disabled or aged, or reportedly "too tired" to respond. This do-nothing group is likely to be less responsive to remedial measures than the other groups.

Compulsory evacuation might be appropriate for the small minority of individuals represented by the 15 percent of our entire sample who did nothing upon hearing the siren because they were foolishly convinced that they were in no danger. However, individuals who wanted to could easily take evasive action. Perhaps the only feasible course is to vigorously prevent such individuals from congregating in dangerous areas for purposes of "sightseeing."

The group of 94 individuals who evacuated upon hearing the siren (32 percent of the 294 who reported their response) presents little or no problem. A desire for safety, awareness of danger, and fear are cited most often as the reasons for immediate evacuation. The individuals who "play it safe" are likely to do so consistently.

A detailed analysis of the large group of 131 people (44.5 percent of the 294) who indicated that they "waited" upon hearing the siren yields interesting conclusions. In answer to the question, "What did you wait for?," by far the largest number of people (60, or 46 percent) indicated that they waited for "another or final siren signal." Thirty-five people did not answer this question; the remainder of this group said they waited for additional information from radio or television, for aid in evacuating, or for "official notification" of the evacuation order.

The next question asked was, "Why did you wait?" Among the 104 individuals who answered this question coherently, the predominant response was that they felt they were, for the time being, in a safe area; 36 replied to that effect. The second most frequent response, made by 20 persons, was that they thought a final signal would be sounded when the impact of the wave was imminent. Other individuals waited to be sure that a wave was actually coming, or waited to receive more definite information.

Table 3. The relationship between ultimate evacuation and the immediate response to the siren.

Immediate response	Total sample		Nonevacuees		Evacuees	
	N	%	*N*	%	*N*	%
Did nothing (continued normal routine)	44	15.0	40	23.3	4	3.3
Evacuated	94	32.0	12	7.0*	82	67.2
Waited (for advice, information, etc.)	131	44.5	100	58.1	31	25.4
Other (returned home, etc.)	25	8.5	20	11.6	5	4.1
Total	294	100.0	172	100.0	122	100.0

*Represents individuals who evacuated upon hearing the siren but returned home prior to time of impact.

We may reasonably hypothesize that the bulk of the parent population falls into the "wait-and-see" group. The 95-percent confidence interval for the relative size of this group extends between 39 and 50 percent (*3*). It is concluded, therefore, that no less than 39 percent, and as high a proportion as 50 percent, of the local population might be expected to "wait" upon hearing a similar disaster warning. Most of the wait-and-see group in our sample made preparations for evacuation as they waited (in vain) for further instructions. Disaster-control agencies should seriously consider the possibility that current warning systems in other communities may produce similar wait-and-see responses.

The three-way classification of victims by their response to the siren may provide an interesting starting point for further research. Independent support of this trichotomy in investigations of personality and reinforcement history would be of both practical and theoretical significance.

Other warnings. To the question, "Did you have information about the wave before it hit, other than the siren?," 66 individuals (20 percent) responded in the negative and 261 (80 percent) in the affirmative. Table 4 summarizes the information sources cited by these 261. Eighty percent of the group (206) said they were listening to radio or watching television.

To the question, "What information did you receive?," 50 (19 percent) did not respond, 159 (61 percent) reported hearing that a tidal wave might have been generated and might be on its way, 22 (8 percent) had heard reports of its arrival in Tahiti, 15 (6 percent) reported hearing of flooding at the Hilo waterfront, hearing that the wave had passed Hilo, or hearing unclear reports. Fifteen individuals (6 percent) reported hearing that an evacuation had been ordered.

Next the 261 individuals were asked why they did or did not take action after hearing the various communications. At least 20 classes of replies were elicited. It seems clear that the communications were ambiguous with respect to the degree of danger and the proper response to the emergency. It appears that each person interviewed was forced to interpret for himself the communications he received, and that these communications were received primarily from radio and television.

Impact Period

Those interviewed were asked, "Where were you when the big wave hit?" Eighty-five of the people responding (43 percent of those who did not evacuate) said they had been at home asleep; 95 persons (48 percent of those who did not evacuate) had been at home awake.

Our analysis here is limited to the victims that did not evacuate. No significant differences in level of education were found between those who were at home sleeping and those who were at home awake (*4*). Why, then, did such a large number of individuals go to bed after an alert had been sounded? Twenty-six (31 percent) of those who were sleeping at the time of

Table 4. Source of information concerning the tidal wave, other than the siren.

Source of information	Individuals reporting	
	N	%
Relatives–friends	45	17.2
Radio–TV	178	68.2
Government (police, firemen, civil defense)	8	3.1
Radio–TV and relatives–friends	22	8.4
Radio–TV and government	6	2.3
Relatives–friends and government	1	0.4
No answer	1	0.4
Total	261	100.0

impact stated that they did nothing when the siren sounded, while only 11 (12 percent) of those who were awake at the time of impact reported that they did nothing on hearing the siren. Almost one-third of those who were sleeping belonged to the do-nothing group of individuals oblivious to the siren warning and convinced of their safety.

In comparing those who were asleep and those who were awake at the time of impact, another suggestive fact emerges. Upon being questioned about the siren, 30 (35 percent) of those who were asleep and 61 (64 percent) of those who were awake at 1:05 A.M. stated that they responded to the siren by waiting. Thus, most of the individuals who waited stayed awake during the period of waiting. This suggests that they interpreted the situation as serious, enough so to warrant staying awake to a relatively very late hour for inhabitants of Hilo. It is during this period of waiting that large numbers of individuals might have been persuaded to evacuate had there been coordinated and unambiguous directions over radio and television and a door-to-door warning by the police.

Fourteen individuals (4.3 percent of the total sample) reported that they were at the shore line at the time of impact, waiting to see the wave.

Post-Impact Period

Among the group of 197 people in the sample who did not evacuate, 112 (57 percent) were trapped in wreckage and 47 (23 percent) were injured. These figures point up the necessity of complete evacuation during a tsunami warning. Public communications during a tsunami alert should emphasize the fact that if a large wave should strike, then over half the people remaining in the danger areas will be buried in wreckage and one-quarter will be injured or killed. This is a straightforward statistical inference drawn from the data given above (*5*).

Six of the individuals who were trapped in wreckage and three who were injured were people who had returned after leaving their homes, or people who had evacuated to an area that suffered damage. Specification of danger zones in the pre-impact period is mandatory.

Table 5 shows who rescued the 118 individuals of our sample who were caught in wreckage. It should be noted that the figures for the firemen, police, and civil defense category and for the "strangers" category may be inaccurate. Because of a power failure at the time of impact, there was almost total darkness (*6*), and no illumination equipment was available during rescue operations. Presumably, victims recognized friends or relatives among the rescuers by their voices.

Sixty-five percent of the people who got out by themselves did so within the first hour after the impact. A sustained and organized rescue effort is a reasonable requirement in such an emergency; in the Hilo disaster, most of those who did not free themselves in the first hour after the impact required help (*7*).

Possible Determinants of Adaptive Behavior

One of the first things that comes to mind in studying the factors associated with adaptive behavior in emergency situations is amount of education. We studied this variable in two connections

A Hilo shopkeeper talks with an interviewer at the site of his store, which was destroyed by the tidal wave.

Table 5. Response to the question, "Who dug you out of the wreckage?"

Response	Individuals reporting	
	N	%
Got out alone	48	40.7
Family or friends	26	22.0
Strangers	9	7.6
Firemen, police, or civil defense	28	23.7
Did not know	5	4.2
No answer	2	1.7
Total	118	99.9

in our investigation of the Hilo disaster.

First, we compared the average amount of education of those who evacuated and of those who did not and found the figures to be 9.2 and 10.1 years, respectively. The difference is too small to be of any practical consequence. Statistically speaking the difference is significant at the 5-percent level (critical ratio, 2.14). Nevertheless, we feel justified in discounting amount of education as a determining factor, because surely it cannot be claimed that a mere 0.9 year of extra formal schooling for evacuees as against nonevacuees accounted for the difference in behavior.

Secondly, we compared the average amount of education of the nonevacuees who were asleep at time of impact with the amount of those who were awake. Those who were asleep had slightly more education, but the difference was not significant (*4*).

Table 1 shows that of the 151 individuals with intermediate or grade-school training, 51 (33 percent) evacuated and 100 (66 percent) did not. Among the 24 victims with varying amounts of college training, 8 (33 percent) evacuated, while 16 (66 percent) did not.

Thus, we have evidence to support the conclusion that formal education is not a determinant of whether or not an individual shows adaptive behavior in the form of evacuating or staying awake during an emergency situation.

Members of the sample were asked, "Have you been through anything like this disaster before?" Four of those interviewed did not respond, 117 (59 percent) of those who did not evacuate and 67 (51 percent) of those who did answered "No"; 77 (39 percent) of those who did not evacuate and 62 (48 percent) of those who did answered "Yes." For individuals who had had previous disaster experience, the difference in the percentages of those who evacuated and of those who did not was 9 percent. This difference yields a critical ratio of 1.61 with a probability of 5.4 percent for a one-tail test. We conclude, therefore, that disaster experience increases the probability of adaptive behavior in subsequent emergencies. However, this increase is only of the order of 9 percent in our sample.

Table 1 gives figures for the various ethnic groups and shows that 69 percent of the Hawaiian members of the sample evacuated. An elaborate mythology exists pertaining to Hawaiian deities and geophysical events (*8*). Perhaps we have here an instance where such beliefs resulted in adaptive reactions.

Our findings have ruled out education and have relegated previous disaster experience to a minor role as a determinant of adaptive behavior in response to ambiguous emergency warnings. Personality factors, such as chronic anxiety, loom large as a possible explanation of the behavior recorded. These conclusions are, of course, subject to cross validation through further research.

References and Notes

1. C. M. Duke, *Science* **132**, 1797 (1960).

2. The research reported here was supported in part by the National Institute of Mental Health, Public Health Service [grant M-4077 (A)] and by the University of Hawaii. This study was made possible through the cooperation of numerous individuals and organizations and the entire scientific community of the Island of Hawaii. Over 30 members of the Hawaii Division of the Hawaiian Academy of Science and other volunteers helped in the interviewing. The Red Cross and a number of church organizations provided information as to the whereabouts of individual disaster victims. Students at the University of Hawaii, Hilo campus, gave willingly of their time and effort, coding questionnaires and assisting in the preparation of this report.

3. These figures are based on findings for 294 individuals who gave coherent answers to the question concerning their behavior after hearing the siren signal. The 95-percent confidence limits were computed without a finite multiplier.
4. A comparison of the average amount of education of those nonevacuees who were asleep and of those who were awake at the time of impact yielded averages of 9.4 and 9.0 years, respectively. The difference is far from being significant at the 5-percent level (critical ratio, <1).
5. The appropriateness of our recommendation concerning public communications during a tsunami alert is substantiated by the calculation of confidence limits for the proportions of victims who were trapped inside wreckage and of those who were injured, among the nonevacuees. The 95-percent confidence interval extends from 50.1 to 63.9 percent for the proportion trapped inside wreckage—figures which justify our saying "over half." The corresponding confidence interval for the proportion of injured among the nonevacuees extends from 17.1 to 28.9 percent, showing that "one-quarter" is a reasonable estimate.
6. The moon was new during this period of May 1960; thus, visibility without artificial illumination was extremely limited.
7. The Hilo Civil Defense Log contained the following entry dated 23 May 1960, 0325 hours: "From Hilo Civil Defense to Central Police Communications Center, 'No one to enter area till daylite [sic].'"

8. R. Lachman and W. J. Bonk, *Science* **131**, 1095 (1960).

Science in the News

Science in the Courts: The Supreme Court Is Asked To Decide on the Inherent Dangers of Nuclear Reactors

An often puzzled Supreme Court last week heard 3 hours of argument on a case that questioned the legality of the procedure the Atomic Energy Commission has been using to permit the construction and operation of nuclear power plants. In 1956 the Power Reactor Development Corporation, a nonprofit corporation supported by 17 private industrial and utility companies interested in atomic power, received a permit to build a power reactor at Lagoona Beach, Michigan, 30 miles from Detroit. The construction permit has been under attack more or less continuously ever since by several of the senior members of the Joint Committee on Atomic Energy and by a group of labor unions, chiefly the electrical and auto workers.

The unions fought the AEC unsuccessfully through its own hearings procedure, then successfully appealed to the courts to have the permit set aside. The government then appealed to the Supreme Court.

Opposing Views

As the unions see it, the AEC cannot let anyone build a reactor unless it is clear that the reactor can operate safely. Their point is that, once someone has spent the $50 million or so to build a power reactor it is not likely that the AEC will tell them their money is thrown away because the reactor is not safe enough to operate. This means, the unions say, that to fully protect the public the AEC must be able to make the same stringent findings of safety at the time it issues a construction permit which, both sides agree, it must make to issue an operating license.

The government's opinion is that the union's view, if upheld, would substantially slow the development of atomic energy applications without substantially adding to the public's protection.

The reason for this, the government says, lies in the nature of the problem: atomic power plants cannot compete with conventional plants, and the only reason for building them is to advance technology toward the point where atomic power will be as cheap as conventional power. Therefore any new atomic power reactor is different from all those built earlier, and to delay each construction permit until all the detailed information is available to support a safety finding for a final design would delay each project for several years. In the government's view, the current procedure involves no risk to the public since the builder realizes that the construction permit will not lead to an operating license unless the final reactor meets the safety requirements. This warning to the builder was repeatedly emphasized in the AEC decision on the PRDC case, partly as an answer to the unions' contention that issuing a construction permit almost automatically leads to an eventual issuance of an operating license.

Technically the question is strictly on whether the law allows the two-step procedure the AEC uses, with the definitive finding of safe operation delayed until the time to issue an actual operating license. What makes the case curious is that the case is really going to be decided on the court's evaluation of the scientific question of how much risk is involved in operating an atomic power plant. "Let's face it," says an attorney who worked on the case for the unions, "the thing that made the lower court throw out the AEC's finding and the thing that's going to make the Supreme Court go the same way is that anyone would have to be crazy to build a reactor like that near a big city."

"The possibilities of harm are so enormous," the lower court said, "that any doubt as to what findings the act requires, and any doubt as to whether the Commission made such findings, should be resolved on the side of safety." What the unions have done is to offer the courts a rationalization for an interpretation of the law that could be used to provide a legal justification of a decision that would really be based on the court's finding that "the possibilities of harm are so enormous." If the law is interpreted in a straightforward way there is not much doubt that the AEC has the right to proceed the way it has been doing. But lawyers recognize that if the judges' feelings are strong enough they can sometimes be persuaded to accept a suggested interpretation which allows them to decide, in effect, what Congress should have done rather than what Congress did.

The government argues that there is nothing in the scientific testimony to support the court's view of the dangers of the reactor. The court, or rather the two of the three judges on the court who supported the union, cited two pieces of evidence to support its view of the dangers, both general statements concerned with the kinds of imaginable nuclear accidents. Neither statement, and nothing in the record, suggested that the AEC regulations would authorize an operating license for a reactor that would make these imaginary accidents a credible possibility.

The unions themselves offered no witnesses to back up their view of the dangers. Their contribution to the scientific testimony consisted primarily of cross-examining the scientific witnesses to emphasize that the findings of probable safety of operation made for the provisional construction permit were not as strict as those that would have to be made for an actual operating license.

The AEC concedes this is true, and will always be true as long as each new power reactor, in order to be worth building, must be substantially different from any earlier reactor. The question for the Supreme Court, then, is whether in their judgment, as men who make no pretense of understanding nuclear technology, the inherent dangers of reactors are so great that the courts must go to great lengths to minimize not only the possibility that the AEC would permit a dangerous reactor to be put in operation, but that the courts themselves would then uphold an AEC decision to allow a dangerous reactor to operate.

Legal Technicalities

The case illustrates the substantial difference between scientific and legal controversy. The case involves rival theories of how the law is to be interpreted. Both sides attempt to develop

evidence for a theory that would account for how the law came to be written as it is, leading to a conclusion that if such is the basis for the wording of the law, then it follows that this is the way the law should be interpreted in this case.

The court must make a decision (it cannot, as in a scientific controversy, simply decide that there is not enough evidence to decide), and that decision, depending on the terms of the court's option, can fall anywhere in the wide area between the union's view that the basic law requires the AEC to make the same safety findings for a construction permit as for an operating license, and the government's implied view that the law allows the AEC great freedom on what regulations it should write on the requirements for a construction permit.

Rival Theories

Each side wants a decision as close to its view as possible. It offers theories that would justify a decision at various points in the gray area between the extremes which are different from, and what is worse, sometimes contradictory of the theory that it would rely on if it wanted to stake everything on the chance of winning complete victory. This raises the danger of arguing so well for a compromise theory that contradicts your main theory that you convince the court your main theory is wrong. In this case the result of such problems was that neither the government nor the unions offered a completely clear presentation of any one theory. The details of the case made this especially true for the unions. From the union's argument (that the law requires the same safety finding for construction as for operation) it seemed to follow that the pertinent AEC regulation (50.35) was itself a violation of the law, for the regulation was designed to allow leeway on a reactor of untried design "where, because of the nature of a proposed project, an applicant is not in a position to supply initially all of the technical information . . ."

The unions never followed this argument through to its apparent conclusion. Instead they emphasized a theory that although regulation 50.35 is legal in itself, it is to be interpreted in a very narrow way. But to interpret the regulation as narrowly as the unions sometimes seemed to argue raised such not unanswerable, but ticklish questions as why the AEC would go to the trouble of writing a regulation whose meaning was so narrow that it really had no more discretion on safety findings that it had without the regulation, or alternatively, if the regulation was to be interpreted slightly less narrowly, but giving the AEC a fair amount of leeway, how the unions' basic premise that the law allowed no leeway could be true.

The Court questioned the union's attorney at length, trying to pin him down on just what he was arguing, but since the confusion resulted from the nature of legal disputation rather than from mere perversity on the part of the union's lawyers, the court showed no special annoyance at the situation. For the unions had merely strived to provide the court with a line of reasoning that could be used to justify any decision the Court might make favorable to the unions, an opinion that would be perfectly coherent once it was divorced from the competing lines of reasoning which had to be presented simultaneously.

News Notes

Conflict of Interest

The President has asked Congress for a wholesale rewriting of the conflict-of-interest laws, a matter of interest to the scientific community since at least a technical case of violation of the current statutes could be made out against most of the more prominent scientists in the country.

The laws, as they stand now, are a collection of seven separate pieces of legislation passed at various times over the last 90 years, five of them dating back to the early post-Civil War days. Most of them were written in response to a particular set of scandals; no two of them use quite the same terminology; and no one is quite sure how they are to be interpreted, since the specific abuses most of them were written to combat are not often the sort of abuses that are matters of concern today.

There is some question whether there was a clear violation of the conflict-of-interest laws in the Welch scandal at the Food and Drug Administration last year, and equally a question of whether nearly every scientist on a government advisory panel is not violating the conflict-of-interest laws, since he normally will be a consultant or staff member of one or more organizations which are receiving research support from the government, usually in the very field in which he is advising the government.

(Welch was simultaneously chief of the FDA antibiotics division and editor of several antibiotics journals. The Kefauver drug investigation turned up information that the "modest honorarium" he told his superiors he was receiving for the editorship was in fact a percentage of the advertising and reprint revenues derived from the antibiotics manufacturers he was supposed to regulate, and came to about $40,000 a year.)

Kennedy has asked Congress to scrap the old laws and substitute a single new statute. This is what has been recommended by a number of committees that have studied the problem in the past 10 years, and the objectives would include both broadening the laws to include clear violations that were not thought of when the earlier laws were written, and writing into the law a clear procedure for granting exemptions in cases, such as those involving most scientists, where the government must necessarily accept some conflict of interest, since the only people qualified to give the advice needed are people who are in a position to benefit, indirectly at least, from what the government does.

As things stand now, the laws are often simply ignored because to comply with them would cut the government off from the very people whose services it most needs.

NASA succeeded last week in another firing which placed the first astronomical satellite in orbit. The 90-pound Explorer XI is a telescope-shaped device intended to gauge the intensity and direction of cosmic gamma radiation. This cannot be done from the earth, for the interstellar gamma rays become mixed with rays created within the atmosphere. The device tumbles over as it orbits. It contains, in addition to gamma ray detectors, earth and sun sensing devices which enable its orientation to be constantly known. This makes it possible to learn the intensity of radiation coming from various directions.

* * *

School segregation, for the first time, is being opposed in a law suit initiated by the federal government. Until now all desegregation suits have been filed by the private citizens affected. A county in Virginia had attempted to circumvent a desegregation order by opening a system of private schools,

supported in part by tuition fees, but mainly by public funds. The Justice Department filed suit claiming this was unconstitutional. This action not only removes any ambiguity about where the Administration stands on the issue, but in effect makes the financial and staff resources of the Justice Department available to share the burden of fighting desegregation cases which, until now, has been borne almost entirely by the National Association for the Advancement of Colored People.

Announcements

Stanford University's Hopkins Marine Station plans to convert the *Pioneer*, a two-masted schooner long owned by philanthropist George Vanderbilt, to a modern sea-going vessel for research in **marine biology**. It will be the largest sailing ship in the world used for scientific purposes. This project is made possible by a grant from the National Science Foundation.

* * *

A translation of a **Soviet lunar atlas**, compiled from the first photographs ever taken of the far side of the moon and including detailed descriptions of the newly revealed areas, as interpreted by Soviet scientists, is available from the Office of Technical Services, Department of Commerce, Washington 25, D.C. $3.

Courses

A course in **general pathology** for graduate students and investigators who do not have a medical background will be offered at the Harvard Medical School this summer (26 June to 15 July) for the first time. The course is supported in part through a training grant from the U.S. Public Health Service. It is primarily organized "for the many investigators working in the biological field who have no formal education in general pathology and who wish to become acquainted with the basic mechanisms of disease at the level of cells and tissues."

* * *

The 1961 Summer Institute in Dynamical Astronomy will be held at the University of Arizona, Tucson, from 10 July to 4 August. This institute, in which college and university teachers of astronomy, physics, and mathematics as well as research workers from government and industry participate, is for scientists who desire an intensive introduction to the field of **celestial mechanics**. In addition to the formal program in astronomy, speakers will discuss current fields of research. (Professor Dirk Brouwer, Yale University Observatory, Box 2023 Yale Station, New Haven, Conn.)

* * *

A series of laboratory **refresher training** courses is to be offered by the Laboratory Branch of the Communicable Disease Center (U.S. Public Health Service), Atlanta, Georgia, from 11 September 1961 to 13 April 1962.

* * *

Two advanced courses in **reactor technology** will be offered again at Oak Ridge National Laboratory, Oak Ridge, Tenn., beginning next fall. The two courses—on reactor operations supervision and reactor hazards evaluation, respectively—are designed principally for students from abroad but are also open to U.S. citizens. The courses start 25 September and run a full year. The tuition for each course is $2000. Deadline for applications is *15 June*.

Grants, Fellowships, and Awards

Epidemiology. Fellowships (full support, tuition, and dependency allowances) are available to M.D.'s and Ph.D.'s in related fields for a 3-year residency in epidemiology, through a grant from the National Institutes of Health. The purpose of the program is "to increase the number of qualified epidemiologists available for public health research, particularly with respect to diseases of non-infectious and unknown cause."

General research. Grants-in-aid, usually ranging between $500 and $1500, are available from funds administered by the American Academy of Arts and Sciences for research in any recognized scientific field. Applications must be received *before 1 September* for grants to be made in October. Applications from individual scientists will be given prior consideration over those from institutions, although this is not an inflexible policy. Projects concerned with exploration of the frontiers of scientific knowledge, whether interdisciplinary or within a single discipline, are preferred. (American Academy of Arts and Sciences, Committees on Research Funds, 280 Newton St., Brookline Station 46, Boston, Mass.)

Heart. Applications from research investigators for support of studies to be conducted during the fiscal year beginning 1 July 1962 are now being accepted by the American Heart Association. The deadline for submitting applications for research fellowships and established investigatorships is *15 September*. The stipends range from $4500 to $9000 per year. Grants-in-aid are also available in support of specified projects. (American Heart Association, 44 E. 23rd St., New York 10)

Meeting Notes

Congenital anomalies. The Japan Association for Study of Congenital Anomalies held its initial meeting at Kyoto University's Faculty of Medicine on 25 February. Approximately 100 scientists in basic and clinical medicine and in related biological sciences attended. The proceedings of this and subsequent meetings will be published in the medical journal *Saishin-Igaku*. The Japan Association welcomes communications from foreign scientists interested in the problem of congenital anomalies. (Dr. Hideo Nishimura, Professor of Anatomy, Faculty of Medicine, Kyoto University, Kyoto, Japan)

* * *

Psychophysiology. The newly formed Society for Psychophysiological Research will hold its first annual meeting in New York on 5 September, in conjunction with the American Psychological Association Convention. The purpose of the society is to foster research on the somatic responses and their psychological relations in a number of different academic disciplines, including psychology, physiology, biology, psychiatry, and instrumentation. (Dr. Albert F. Ax, Secretary-Treasurer, Lafayette Clinic, 951 E. Lafayette, Detroit 7, Mich.)

Scientists in the News

Melvin B. Gottlieb will become director of Princeton University's plasma physics laboratory (formerly Project Matterhorn) on 1 July. He has been associate director of the laboratory and head of the experimental division. He succeeds **Lyman Spitzer, Jr.**, who

has headed controlled fusion research at Princeton since its inception in 1951, and who will now concentrate his efforts on the experimental program with the C stellarator, which is nearing completion.

Ray L. Sweigert, dean of the graduate division of Georgia Institute of Technology, is retiring after 32 years of service.

Isaac D. Welt, formerly on the staff of the division of medical sciences, National Academy of Sciences–National Research Council, has been named chief of the Washington office of the Institute for the Advancement of Medical Communication. Welt is also an associate director and member of the board of directors of the institute. He will continue as director of the cardiovascular literature project, for which the institute now assumes responsibility.

For the best paper presented at the 1960 meetings of the American Oil Chemists' Society, **H. K. Mangold** of the Hormel Institute, Austin, Minn., was named winner of the society's annual Bond award.

Leonard Carmichael, secretary of the Smithsonian Institution, Washington, D.C., was elected president of the section on experimental psychology and animal behavior of the International Union of Biological Sciences at the meeting held in Amsterdam on 29 March. He succeeds H. Piéron of the Sorbonne.

Daniel Binder, formerly a physicist with Oak Ridge National Laboratory, has joined Hughes Aircraft Company's nuclear electronics laboratory as head of the nuclear measurements department.

Emil Palmquist has been appointed medical director of the regional office of the Department of Health, Education, and Welfare in Charlottesville, Va., where he will be responsible for the administration of grants-in-aid and various types of technical assistance which the Public Health Service makes available to the health departments of the District of Columbia, Kentucky, Maryland, North Carolina, Virginia, West Virginia, Puerto Rico, and the Virgin Islands. Palmquist is at present a public health consultant in HEW's San Francisco regional office. In Charlottesville he will replace **Eugene Gillis**, who recently became health officer of Philadelphia.

George A. Wolf, Jr., dean of the University of Vermont College of Medicine, has been named executive director of the Tufts-New England Medical Center, Boston. Wolf will also be named vice president for medical affairs of Tufts University. His appointment to both positions will become effective on 1 September.

Grete Lehner Bibring has been named clinical professor of psychiatry on the Harvard University faculty of medicine. She is psychiatrist-in-chief at the Beth Israel Hospital, Boston, and president-elect of the American Psychoanalytic Association.

Taffee T. Tanimoto, mathematician, has been named head of the Pattern Recognition Laboratory in the Melpar Corporation's Applied Science Division, Watertown, Mass. He joins Melpar from International Business Machine's research center at Yorktown Heights, N.Y., where he was engaged in computer-oriented mathematical research—principally theoretical work in information retrieval.

Deane B. Judd has been appointed editor of the *Journal of the Optical Society of America*. Judd, a physicist at the National Bureau of Standards since 1927, is internationally known for his work in colorimetry and on color vision. He is a former president of the society and has served as associate editor of its journal for many years.

Don W. Esplin, assistant research professor of pharmacology at the University of Utah College of Medicine, has received the 1961 John J. Abel award of the American Society for Pharmacology and Experimental Therapeutics for his research on the site and mechanism of drug action in the central nervous system. The award is sponsored by Eli Lilly and Company.

Martin M. Cummings and **Robert H. Grant** have been appointed chief and assistant chief, respectively, of the new Office of International Research at the Public Health Service's National Institutes of Health, effective 1 July.

Cummings has been chairman of the department of microbiology at the University of Oklahoma Medical School since 1959. In addition to his administrative and teaching duties there, he has conducted research in epidemiology, microbiology, and clinical medicine and has served as consultant to the Veterans Administration and the Medical Research Foundation of Oklahoma.

A career Civil Service employee, Grant has for the past year been on leave from his regular post as executive officer of the National Heart Institute, to serve as director of the Special Staff on Aging for the Department of Health, Education, and Welfare.

Recent Deaths

Ernest F. Cook, Philadelphia, Pa.; 83; professor emeritus of pharmacy at the Philadelphia College of Pharmacy and Science; former director of pharmaceutical laboratories at the college, of which he was a trustee; was coeditor of *Remington's Practice of Pharmacy*, and for 40 years served as chairman of the Committee on Revision of the *United States Pharmacopoeia*; 2 Mar.

George O. Hendrickson; 70; professor of zoology and entomology at Iowa State University, where he had been in charge of research on wildlife management for 35 years; 19 Mar.

Carl I. Hovland, Hamden, Conn.; 48; professor of psychology at Yale; consultant at various times to the Ford Foundation, the Rockefeller Foundation, the Bell Laboratories, the Center for Advanced Study in the Behavioral Sciences at Stanford, and various government agencies; had recently been awarded the Warren medal of the Society of Experimental Biologists for "distinguished research in higher attitude formations and reasoning"; 16 Apr.

Fred S. Hultz; 67; president of North Dakota State University since 1948; previously professor of animal husbandry at the University of Wyoming for 25 years; 17 Apr.

Erratum: In the report "Slowing of heart rate after septal self-stimulation in rats," by R. B. Malmo [*Science* **133**, 1128 (14 Apr. 1961)], there is a transposition of values for heart rate given in two successive sentences beginning with line 21, column 1, page 1129. The sentences should have read: "Systematic quantitative analysis of the heart-rate data for this animal showed that mean heart rate for periods with self-stimulation was 389.4 beats per minute compared with 442.2 beats per minute for preceding periods without intracranial stimulation. Corresponding mean values for subjects 6 and 10 that also had the five full-training sessions were 442.8 and 451.2 for subject 6, and 400.8 and 428.4 for subject 10.

Book Reviews

The Atoms Within Us. Ernest Borek. Columbia University Press, New York, 1961. xv + 272 pp. Illus. $5.
The Coil of Life. The story of the great discoveries in the life sciences. Ruth Moore. Knopf, New York, 1961. xxvii + 418 pp. Illus. $5.95.

Who should explain science to laymen? Should it be scientists, converted or diverted from their usual work, or should it be journalists, who specialize in science writing? Whether or not there is a general answer, these volumes present an interesting case study of this question. The author of the first is a biochemist, of the second, a journalist. Comparison and contrast have some meaning because both authors are experienced and skillful.

The subject is molecular biology, and both book jackets are ornamented with DNA helices, indicating fairly what lies within. Both authors wisely (I think) approach present problems by the historical route. Ernest Borek traces a path through enzymes, vitamins, intermediary metabolism, isotope techniques, and the architecture of proteins, reaching (after side trips through the blood system and cellular defenses) deoxyribonucleic acid (DNA), with a third of the book to go. Ruth Moore begins with a brief eulogy of DNA and then presents a flashback to Lavoisier and the early days of cell theory and Mendelian genetics. Before she begins the extended discussion of DNA she, too, has used up two-thirds of her book; but unlike Borek, she devotes most of the remaining third to DNA and its ramifications, discussing in considerable detail problems of duplication, of the synthesis of ribonucleic acid (RNA), of coding, and of protein structure. Her book is the larger of the two by some 50 percent.

Although there are many differences in detail, each book deserves high praise for admirably doing the job it sets out to do, namely exhibiting the beauties of molecular biology, including the exciting developments of the last decade, to the man in the street. Whether John Doe will get the message is, of course, another problem. Probably he won't; after his day of quiet desperation, he will probably flee, via television, to "77 Sunset Strip." But Doe's yet unfrustrated son or daughter may pick up one of these books in the high school library, and be rewarded.

Of adverse criticism there is little to offer, but here significant contrasts between the two books are discernible. The faults of the authors spring, I think, from a sort of overcompensation. It is a common complaint that journalists know too little of what they write about. Such a criticism cannot be made about Moore, who had done her homework well. But, aware (I suspect) of this type of critical comment, she has retailed rather too much information, particularly about the early history of biology. There are too many highlights and side lights for the reader easily to see the big picture.

The balance is better in Borek's volume, and his writing also conveys more of a feeling of authority, as one would expect. (Does the layman notice this? One wonders.) But the biochemist commits his own characteristic errors of compensation. Aware, no doubt, of laymen's allergy to diagrams and symbols, Borek announces at the outset: "I use no chemical formulas in this book." This is surely a severe restriction for a book about biochemistry, but he adheres to it for more than a hundred pages, until he takes up the story of the synthesis of insulin by Sanger and his co-workers. Borek tells this detective story very well, but only by using structural formulas. He could hardly do otherwise. Unfortunately, he then apparently remembers his original promise and returns to formula-free exposition. Skilled as Borek's writing is, it is difficult to believe that the reader can get as clear an idea of the hereditary mechanism from words alone as he can get from Moore's diagram-rich text.

So we have the curious contrast of the journalist freely and effectively employing formulas and diagrams, while the scientist avoids them. Borek's motivation and intention are clear and praiseworthy—to avoid parochial cant. But has he not thrown out the baby with the bath? Paraphrasing Willard Gibbs, Borek says (page 114): "Gentlemen, the sciences *are* humanities." But do these humanities not have their own characteristic art forms—namely formulas, diagrams, and graphs? To eschew the appropriate forms is to risk losing the art. In writing his *Essai Philosophique sur les Probabilités*, Laplace achieved the tour de force of describing probability theory without using algebra, but the result has proved useful to neither scientists nor laymen. Laplace's essay is longer, more difficult, and less artistic than the equivalent algebraic exposition would have been. Every artist, and that includes the scientist, must insist on the appropriateness of his tools and media if the audience is to understand what he is trying to say.

One more contrast deserves mention. Borek's book, *The Atoms Within Us*, has no literature citations, whereas *The Coil of Life* closes with a carefully chosen and well-annotated bibliography. For the terminal reader who will pursue the topic no farther (and who admittedly is in the majority), a bibliography is a useless luxury. But for the small fraction of young readers who are fired by an introduction to delve deeper into a subject, such an aid is almost as important as the text itself. If science is, as we think, an endless frontier, we should leave open the paths that lead to it.

GARRETT HARDIN
Department of Biological Sciences, University of California, Santa Barbara

The Geology of the U.S.S.R. A short outline. D. V. Nalivkin. Translated from the Russian by S. I. Tomkeieff. J. E. Richey, Translation Editor. Pergamon, New York, 1960. ix + 170 pp. 2 maps. $15.

A book that summarizes the geology and mineral resources of one-sixth of the land surface of the earth is of paramount interest to geologists and economists, especially when the area involved is one so little known beyond its boundaries as the Soviet Union. Indeed, we could not have read such a book

even in Russian before 1957, and the last comprehensive account, in English, of the geology of Russia is more than a century old, and excluded Siberia.

The Geology of the U.S.S.R. is, in effect, an extended explanation of the English language version of a special edition, on a scale of 1 to 7.5 million, of the new geological map of Russia, prepared for foreign distribution by the Ministry of Geology of the U.S.S.R. The map itself, in full color and excellent registration, is a superb example of geologic cartography. The translation of the text was prepared with the cooperation of Academician Nalivkin himself, dean of Russian geologists and perhaps the only man living or dead who could have written such a book as sole author.

The text consists of a sequence of brief synoptic surveys of major geographic, stratigraphic, tectonic, and magmatic features and of mineral and mineral-fuel resources of each of the ten principal physiographic and geologic subdivisions of the Soviet Union. Such a document can hardly be considered light reading, and few will want to read it from cover to cover. It is, nevertheless, an invaluable source book whose study is facilitated by a detailed index which, in addition to page references, gives the latitude and longitude of localities on the map.

It would be meaningless to attempt here to discuss such condensed subject matter in any detail, but a few items are of sufficiently broad or unusual interest to deserve mention. One is the vast extent of permanently frozen ground in Siberia, much of it with a forest cover, and extending at places to as much as 20 degrees south of the southern limit of Pleistocene continental glaciation. Other matters of special interest include the great thickness and extent of late Precambrian sediments and Nalivkin's opinion that the Siberian archaeocyathids are, after all, mainly Early and not primarily Middle Cambrian as now widely believed. The picture of Soviet mineral resources which emerges from the various sectional accounts is one of unspecified but allegedly ample reserves of most of the important industrial and precious minerals and mineral fuels, with the possible exception of oil.

Incidentally, those who wish to inquire more deeply into the subject of this book will find it treated extensively in a three-volume, multiauthor compendium, *The Geological Structure of the U.S.S.R.*, published in Russian (1959) and available in a French translation from Service d'Information Géologique (B.R.G.G.M., 74 rue de la Fédération, Paris 15). A geological map of the Soviet Union in 18 sheets, at a scale of 1 to 2.5 million, with Russian and English explanations, and published in 1956, is also available from the Soviet Ministry of Geology.

PRESTON E. CLOUD, JR.
U.S. Geological Survey, Washington, D.C.

Mammals of Wisconsin. Hartley H. T. Jackson. University of Wisconsin Press, Madison, 1961. xii + 504 pp. Illus. $12.

The Recent Mammals of Arizona: Their Taxonomy and Distribution. E. Lendell Cockrum. University of Arizona Press, Tucson, 1960. viii + 276 pp. Illus.

Mammals of Wisconsin is the result of more than 3½ years of field work carried out between 1917 and 1951 by Jackson and his associates in the Fish and Wildlife Service and the Wisconsin Conservation Department. Additional years were given to the examination of thousands of specimens (including 6300 Wisconsin specimens), compilation of information from the extensive literature, and selection of hundreds of illustrations. Most of the book (414 pages) is devoted to accounts of the Recent mammals: artificial keys for identifications down to families and sometimes to genera and, for the 84 species or subspecies, sections on common names, descriptions, identification criteria, distribution in the state, status, habits, and specimens examined. There are maps showing state and continental distribution of each kind of mammal, and line drawings and photographs of skulls, teeth, and other diagnostic parts and of tracks, scats, burrows, nests, and so forth. The illustrations have been chosen with great care to show important characteristics of various species. A 46-page bibliography and a 19-page index conclude the volume. In composition, design, and typography it is top-grade but, to keep the cost within reasonable limits, some quality has been sacrificed in reproducing the photographs.

The book is highly readable and is a mine of information on occurrence, habits, economic and other values, and management. It will be invaluable to professional and amateur mammalogists and "mammal-watchers," not only in Wisconsin but throughout the north central states and western Ontario.

Because Arizona is ecologically complex and new facts bearing on the evolution and distribution of mammals are still being uncovered, that state is not ready for a comprehensive treatise. *The Recent Mammals of Arizona* is a summary of known distributional and taxonomic data. An identification key for the 290 species and subspecies currently recognized as occurring in Arizona is followed by an account of each kind of mammal; this account includes synonomy, distribution in the state, specimens examined, and additional records. Collecting localities of the specimens are shown on range maps (111) that are sufficiently large and uncluttered to serve their purpose effectively. There is a 15-page bibliography but no index. Cockrum, a professor of zoology at the University of Arizona, has produced a basic book which will be indispensable to every mammalogist working in Arizona for many years to come.

VICTOR H. CAHALANE
New York State Museum, Albany

Handbook of Textile Testing and Quality Control. Elliot B. Grover and D. S. Hamby. Textile Book Publishers (Interscience), New York, 1960. vi + 614 pp. Illus. $17.50.

In the first nine chapters Grover and Hamby illustrate how to make various statistical calculations from observed data. The formulas are simply given, the meanings of the symbols are stated, but the reader is spared the derivations, which can be found in many standard texts. Numerical data, typical of a textile process or of an experiment, are tabulated, and the numerical calculations are indicated step by step. Results are interpreted in the language of a textile technologist, and their use is illustrated by means of quality control charts with upper and lower control limits. These treatments cover both quantitative and qualitative data, such as the strength of a product and the fraction or percentage found to be defective during a given period or quantity of production. Pertinent problems are included for use in mastering the calculations and in establishing quality control charts, drawing conclusions, and recommending courses of action or remedies.

In the next ten chapters the authors discuss various factors that may influence the quantities measured. These factors include, among others, the humidity in the plant; the grade, length, and fineness of fiber used in manufacture; and typical changes in machine operation. Again adequate and typical data are presented, the calculations are illustrated, and the results are evaluated for practical use.

The remaining 14 chapters discuss textile testing methods and instruments; for each quantity, practical data, drawn from normal textile experiments or operations, are presented together with the necessary calculations, evaluations, and appropriate recommendations. The book concludes with a number of informative tables—for example, names and descriptions of common textile defects, their sources and causes, and places of responsibility.

The authors adequately attain their objective of providing a book for practical use by executives, technologists, and students of textiles.

HERBERT F. SCHIEFER
Textile Section,
National Bureau of Standards

Stars and Stellar Systems. vol. 1, *Telescopes*. Gerard P. Kuiper and Barbara M. Middlehurst, Eds. University of Chicago Press, Chicago, Ill., 1961. xv + 255 pp. Illus. $8.50.

Tools of the Astronomer. G. R. Miczaika and William M. Sinton. Harvard University Press, Cambridge, Mass., 1961. viii + 294 pp. Illus. $7.75.

In the burgeoning society of scientific instruments, astronomical telescopes are real aristocrats. Among the parvenus—the synchrotrons, transistors, nuclear magnetic resonance spectrometers, and the like—the present generation of telescopes stand apart as the obvious, direct, lineal descendants of the instruments which first searched the skies three and a half centuries ago. Galileo or Newton would have no great difficulty in recognizing a modern telescope or in comprehending its purpose. This is because the instrument is essentially a simple one, with the simple function of forming images of celestial objects. Sometimes the emphasis is on images of large scale; more often nowadays it is on high light flux.

Compared with most research tools, the astronomical telescope has certainly shown a remarkably well-ordered, slow, and steady evolution. Even individual telescopes are long-lived compared with most research instruments: more than 50 years after its erection by George Ellery Hale, the 60-inch reflector on Mount Wilson is still in nightly demand for astronomical research. All this is not to deny that there have been important advances in the art of telescope-making. The moving parts of the Hale telescope weigh 530 tons; but the 17-foot mirror is figured to such perfection and it is mounted and moved with such delicacy, that it is regularly capable of concentrating within a 50-micron circular image 80 percent of the light of a star on its optical axis and of maintaining the shape and position of the image for hours as the star moves across the sky.

Side by side with the increasing refinement of telescopes, and with their growth in size and light-gathering power, there has occurred a vigorous development of the instruments that are auxiliary to telescopes. Here the pace has accelerated in recent years, and we have seen the emergence of entirely new techniques. Among all the receptors used with the 60-inch telescope on Mount Wilson, only the eye remains as it was 50 years ago; and the eye is virtually never used for observations. The photographic plates, the photometers, the spectrographs—all the paraphernalia of detection and measurement—are vastly different now, and much better.

The Kuiper-Middlehurst book limits itself to telescopes themselves, leaving the description of the auxiliary equipment to another of the proposed nine-volume compendium of stellar astronomy and astrophysics. Thirteen authors contribute chapters describing the various kinds of modern astronomical telescopes that are useful in these areas; radio telescopes are included. Two of the most interesting chapters discuss astronomical "seeing" (that is, atmospheric effects on image quality) and observatory site selection. Each author writes authoritatively. The volume is addressed to astronomers, or to others who have training in science or engineering.

The Miczaika-Sinton book, on the other hand, addresses itself to the nonprofessional reader, the college undergraduate, or the astronomy buff. Moreover, it includes a discussion of the various kinds of detectors, of solar telescopes, and of the numerous auxiliary devices that are used in astronomy: the spectrographs, photometers, measuring engines, and so forth.

If any criticism is leveled at these volumes, it could be on the score that neither makes it quite clear just how much the design of a telescope is ultimately governed by the properties of the detector used with it. There are revolutionary developments afoot in detector technology now, and these are likely to have a major impact on the design of future telescopes. But whether or not they clearly herald such imminent changes, these are both first-rate books. Especially at this time, when so many in other branches of science and engineering have found a sudden incentive to learn about astronomical instruments, *Telescopes* and *Tools of the Astronomer* are certain to be well received and widely used.

ARMIN J. DEUTSCH
Mount Wilson and Palomar Observatories, Carnegie Institution of Washington, California Institute of Technology

Russian for Scientists. Dennis Ward. Macmillan, New York, 1960. 204 pp. $3.95.

This compact manual aims to help beginners achieve adequate skill in reading scientific texts. The materials on grammar are presented capably, clearly, and in judicious sequence. In his treatment of forms, the author emphasizes "markers"—that is, distinctive graphic features—an approach which I find to be generally successful. Illustrative sentences for translation from Russian to English (but not from English to Russian) are abundant and varied, with ample and excellent vocabulary help given on the spot. The table of verbs included in the index will be useful to some. The end vocabulary is excellent and complete. The entire work, including the printing, demonstrates great care.

I recommend two minor improvements that could be made as additions in the appendix. Aside from three selections in the middle of the book there are no "readings" with connected discourse. I would like to see the student rewarded with a few morsels to read (with some aids) before he "graduates." Since so much attention is given to the markers, I believe that an alphabetical index of them would be useful.

Here are some recommended vo-

cabulary additions: ряд: a large number; лéто (*in the singular*): summer, *not* year; картúна: situation; при э́том: moreover, at the same time, in this connection; наблюда́ться: to occur.

This is an excellent guide for initiates in or outside of a class. Moreover, science students with a background in general Russian should find this a useful review grammar and builder of basic scientific vocabulary, well worth covering before essaying genuine texts.

NORMAN HENLEY
Johns Hopkins University and
Goucher College

Mathematical Thinking in the Measurement of Behavior. Herbert Solomon, Ed. Free Press, Glencoe, Ill., 1960. 314 pp. $7.50.

Within this volume are three distinct monographs, each representing a survey of mathematical approaches to selected problems in social science. The first and longest is "The Mathematical Study of Small Groups," by James S. Coleman (150 pages). Ernest W. Adams has contributed "Survey of Bernoullian Utility Theory" (118 pages), followed by "A Survey of Mathematical Models in Factor Analysis" (46 pages) contributed by the editor. All were prepared as part of the program of the Bureau of Applied Social Research of Columbia University and were initiated during the period 1952–56.

Coleman begins by considering explanations for the relative paucity of mathematical models for behavior of small groups, then examines in detail several models which have been proposed, systematically discussing the purpose and the advantages and shortcomings of each. The 21 pages that constitute the evaluation of approaches toward model-building in the social sciences should be recommended reading for all students of mathematical social science. Indeed, it is this critical assessment of model-building strategies which serves to motivate the entire monograph. Models are separated into two types, those based upon empirically verified postulates, in which case theorems have predictive status, and models based upon verified theorems, in which case empirical confirmation of the postulates becomes of interest. When a proposed model can be characterized by neither form of correspondence with empirical observation, one can wonder, with Coleman, concerning its role in science.

The second monograph, by Ernest Adams, includes critical examination of the assumptions of Bernoullian utility theory, notes some suggested modifications of the theory (for example, incorporation of subjective probability), presents an introduction to decision theory, and finally discusses attempts to verify empirically certain aspects of utility theory. The monograph serves as a useful introduction to these topics, which have become a focus of increasing attention from social scientists in recent years.

In the final paper, Solomon presents a chronological history of factor analysis, considering each major theory as a mathematical model for observed data.

This volume may not completely fulfill the expectations of some readers, misled by the implied breadth of its title. Such readers, however, are not likely to be permanently disappointed. The decision to present detailed analysis of a few representative topics rather than superficial coverage of many was a wise one. The three contributions are of high quality and equip the reader, whether graduate student or research worker, with considerable understanding of the criteria for useful formalization of theory in social science.

LYLE V. JONES
Psychometric Laboratory, University of North Carolina, Chapel Hill

New Books

Biological and Medical Sciences

Biological Problems Arising from the Control of Pests and Diseases. R. K. S. Wood. Inst. of Biology, London, 1960. 128 pp. 25s.

The Cell Nucleus. J. S. Mitchell, Chairman. Academic Press, New York, 1960. 282 pp. Illus. $11. Proceedings of an informal meeting held at the Department of Radiotherapeutics, University of Cambridge, 31 August–1 September 1959 by the Faraday Society.

Cell Physiology of Neoplasia. Published for the M. D. Anderson Hospital and Tumor Institute. Univ. of Texas Press, Austin, 1960. 661 pp. Illus. $10.50. Papers presented at the 14th annual symposium on fundamental cancer research, 1960.

The Infectious Diseases of Domestic Animals. With special reference to etiology, diagnosis, and biologic therapy. William Arthur Hagan and Dorsey William Bruner. Cornell Univ. Press, Ithaca, N.Y., 1961. 1051 pp. Illus. $11.50.

International Review of Cytology. vol. 10. G. H. Bourne and J. F. Danielli. Academic Press, New York, 1960. 423 pp. Illus. $13.

An Introduction to the Mathematics of Medicine and Biology. J. G. Defares and I. N. Sneddon. Yearbook, Chicago, Ill., 1960. 675 pp. Illus. $14.

Introduction to Parasitiology. With special reference to the parasites of man. Asa C. Chandler and Clark P. Read. Wiley, New York, ed. 10, 1961. 834 pp. $9.75.

Introductory Botany. Arthur Cronquist. Harper, New York, 1961. 903 pp. Illus. $9.25

A Laboratory Manual of Analytical Methods of Protein Chemistry (Including Polypeptides). vol. 2, *The Composition, Structure, and Reactivity of Proteins*. P. Alexander and R. J. Block, Eds. Pergamon, New York, 1960. 528 pp. Illus. $14.

Laennec, His Life and Times. Roger Kervran. Translated from the French by C. D. C. Abrahams-Curiel. Pergamon, New York, 1960. 223 pp. $3.50.

Medicine Makers of Kalamazoo. Leonard Engel. McGraw-Hill, New York, 1961. 269 pp. $4.50.

The Nervous System. G. M. Wyburn. Academic Press, New York, 1960. 191 pp. Illus. $5.

New Approaches in Cell Biology. P. M. B. Walker, Ed. Academic Press, New York, 1960. 216 pp. Illus. $6. Proceedings of a symposium held at Imperial College, London, July 1958.

Pêches Continentales. Biologie et aménagement. R. Vibert and K. F. Lagler. Dunod, Paris, 1961. 744 pp. Illus. NF. 88.

Physical Chemistry for Students of Pharmacy and Biology. S. C. Wallwork. Longmans, Green, New York, ed. 2, 1961. 369 pp. Illus. Paper, $3.75.

The Physiological Basis of Medical Practice. A text in applied physiology. Charles Herbert Best and Norman Burke Taylor, Eds. Williams and Wilkins, Baltimore, Md., ed. 7, 1961. 1570 pp. Illus. $16.

The Physiology of Crustacea. vol. 2, *Sense Organs, Integration, and Behavior*. Talbot H. Waterman, Ed. Academic Press, New York, 1961. 695 pp. Illus. $23.

The Practical Application of Medical and Dental Hypnosis. Milton E. Erickson, Seymour Hershman, and Irving I. Secter. Julian Press, New York, 1961. 480 pp. Illus. $12. Publication of the Seminar on Hypnosis Foundation.

Progress in Endocrinology. pt. 1, *Neuroendocrinology and Endocrinology of the Thyroid and Parathyroid Glands*. K. Fotherby, J. A. Loraine, J. A. Strong, and P. Eckstein. Cambridge Univ. Press, New York, 1960. 176 pp. $8.50.

Radiation Protection and Recovery. Alexander Hollaender, Ed. Pergamon, New York, 1960. 392 pp. Illus. $10.

Recent Advances in Renal Disease. M. D. Milne, Ed. Lippincott, Philadelphia, Pa., 1961. 263 pp. Illus. $5. Proceedings of a conference held at the Royal College of Physicians, London, July 1960.

Remington's Practice of Pharmacy. Eric W. Martin *et al.*, Eds. Mack, Easton, Pa., ed. 12, 1961, 1886 pp.

Vergleichende Physiologie. vol. 5, *Physiologie der Erfolgsorgane*. W. von. Buddenbrock. Birkhauser, Basel, Switzerland, 1961. 390 pp. Illus. F. 54.

Reports

Afferent Units in Dorsal Roots of Cat Driven by Respiration

Abstract. Single-fiber activity synchronous with breathing was recorded from the dorsal roots of thoracic segments in anesthetized cats. Activity of these fibers varied in frequency and in phase relationship to the respiratory cycle. It is concluded that large numbers of proprioceptors within the thoracic wall are activated during each inspiration and each expiration.

The factors establishing the rhythm of breathing remain incompletely understood. Unquestionably, however, this rhythm is affected by peripheral receptors which rhythmically discharge into the central nervous system (*1*). Signals arising from receptors in the lungs have been studied extensively (*2*). However, comparatively little is known about the activity of receptors lying within the thoracic wall. This report presents evidence that numbers of these, and possibly others in the abdominal wall, are stimulated during each inspiration and expiration (*3*).

The studies were performed on adult cats initially anesthetized with sodium pentobarbital (40 mg/kg) and maintained under general anesthesia with supplementary doses. Simultaneous records were obtained of breathing and of the activity of single afferent fibers in the dorsal roots. The latter were exposed from T_2 to T_{10} by laminectomy. Rootlets to be studied were severed at the point of their entrance into the cord and were dissected to progressively finer filaments which were laid across a wire electrode. Potential differences between this and a bulldog clip placed on paraspinal tissue or retractor were monitored by speaker and oscilloscope. The exposed cord was covered by mineral oil. The cat's temperature was regulated at 37°C. Breathing was recorded by suspending a thermistor in the tracheal cannula and displaying on an oscilloscope the temperature changes resulting from air flow. Records were made from 65 separate single units in nine cats.

The representative records in Fig. 1 show that both inspiration and expiration either modified an existing pattern of discharge in a dorsal root fiber or initiated activity where there had been none.

Different neurons exhibiting activity synchronous with breathing varied with respect to frequency of discharge, phase of the respiratory cycle during which rate of firing was highest, and proportion of cycle during which activity either increased or decreased. Frequencies varied from approximately 10 per second to 60 per second. Peak frequencies appeared at all parts of the cycle. Most fibers, however, could be classified as either inspiratory or expiratory, depending on the part of the cycle during which frequency of discharge was highest. Of the 65 single-fiber preparations studied, 31 were classified as inspiratory, 19 as expiratory, and 15 as unaffected by respiration. The pattern of activity in a given single fiber varied little from breath to breath. Some fibers were active throughout the entire cycle, their frequency of discharge varying constantly during either inspiration or expiration. Other fibers were silent except for a brief burst of activity during a small fraction of the cycle. The pattern of discharge of most fibers fell between these two extremes.

Some cats were given curare or succinylcholine in amounts sufficient to produce respiratory paralysis. In these, the discharge frequency of inspiratory or expiratory units was proportional to the degree of lung inflation or deflation. Frequency remained relatively constant in both inspiratory and expiratory fibers when the dimensions of the chest were kept constant in either inspiration or expiration by occlusion of the tracheal cannula.

Removing the skin from the thorax had no effect on neuronal activity. One could identify in some animals an area of a few square millimeters from which bursts of firing could be precipitated coincidentally with delicate probing of the denuded thoracic wall. In such an area, 0.5 cm^2 of 1 percent procaine completely blocked this response as well as activity synchronous with breathing.

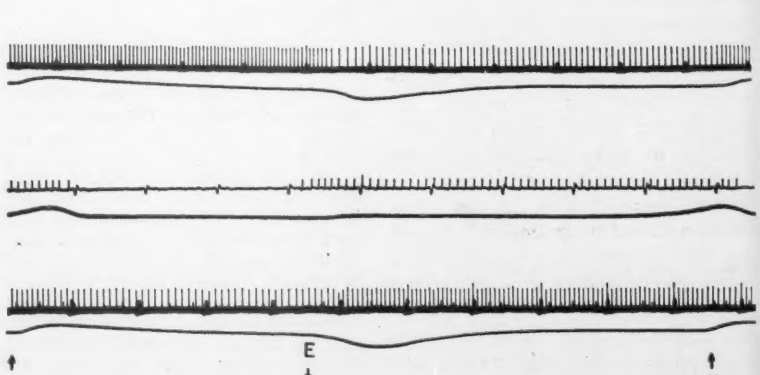


Fig. 1. Four examples of single-fiber activity synchronous with breathing. In each example the upper trace shows single fiber action potentials and the electrocardiogram. The lower trace is a record of the respiratory cycle, an upward displacement indicating the beginning of inspiration (*I*), and a downward displacement the beginning of expiration (*E*). The first two records are of units which fired more frequently during inspiration than expiration (inspiratory units). The third and fourth tracings show expiratory units. Note variations in maximal frequencies and in phase of cycle during which activity is greatest.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

Left pneumonectomy was performed in one cat in order to test the possibility that the receptors being studied were located in the lungs. Discharge patterns in single fibers of the left dorsal roots could not be distinguished in this animal from patterns recorded in animals with intact lungs.

These data show that the expansion and retraction of the chest during breathing produces intermittent activity of receptors in the thoracic wall, just as inflation and deflation of the lungs causes periodic discharge of pulmonary receptors. These thoracic wall receptors are collectively a prolific source of afferent signals rhythmically coursing into the spinal cord and conceivably ascending to higher centers. Boruchow and Nelson (*4*) have identified unitary activity coincident with respiration in the dorsal columns at the level of the third and fourth cervical segments. Yamamoto, Sugihara, and Kuru (*5*) have found fibers in the posterior funiculus of the thoracic region which appeared to discharge in phase with respiratory movements. The activity recorded in ascending tracts by these authors may well have originated in receptors within the thoracic wall. Its physiological effects could be manifest at the segmental level or higher.

The fact that discharge frequency was proportional to chest deformation and that adaptation of these receptors was slow is compatible with their being proprioceptors. The receptors which were specifically localized were in the lateral thoracic wall; they could have been in muscle, fascia, periosteum, or parietal pleura. There is, in addition, the possibility that receptors in the diaphragm, abdominal wall, and costal articulations with vertebrae and sternum are activated by the motions of respiration.

It was concluded that inspiratory and expiratory responses could not necessarily be ascribed to the contraction of an inspiratory or an expiratory muscle. Conceivably, contraction of either type of muscle could produce discharge on inspiration or expiration, depending on whether the receptor being studied was in parallel (muscle spindle) or in series (tendon receptor) with the muscle (*6*).

Literature on the neural regulation of respiration over recent decades has included scant reference to the possibility that thoracic proprioceptors participate in establishing the rhythm of breathing. The older literature, however, contains specific references to this topic. Luciani's textbook, *Human Physiology*, published near the turn of the century, accounts for the respiration after vagotomy as "due to the rhythmical and alternate excitation of the sensory paths of the inspiratory and expiratory muscles" (*7*). In 1917, Coombs and Pike (*8*) demonstrated that sectioning the thoracic and cervical dorsal roots of cats resulted in a diminution or cessation of costal breathing. The afferent streams of rhythmic activity recorded in the present studies are a reasonable basis for these observations (*9*).

A. A. Siebens
F. Puletti*

Department of Physiology, Medical School, University of Wisconsin, Madison

References and Notes

1. A. Liljestrand, *Physiol. Revs.* **38**, 691 (1958).
2. E. Hering and J. Breuer, *Sitzber. Akad. Wiss. Wien Math. naturw. Kl.* **57**, 672 (1868); G. C. Knowlton and M. G. Larrabee, *Am. J. Physiol.* **147**, 100 (1946); J. G. Widdicombe, *J. Physiol. London* **123**, 55, 71, 105 (1954).
3. A. Siebens and F. Puletti, *Physiologist* **2**, 96 (1959).
4. I. Boruchow and J. Nelson, *Federation Proc.* **18**, 14 (1959).
5. S. Yamamoto, S. Sugihara, M. Kuru, *Japan. J. Physiol.* **6**, 68 (1956).
6. B. H. Matthews, *J. Physiol. London* **78**, 1 (1933).
7. L. Luciani, *Human Physiology*, 5 vols., F. Welby, trans. (Macmillan, London, 1911), vol. 1, p. 468.
8. H. C. Coombs and F. H. Pike, *Am. J. Physiol.* **45**, 569 (1917).
9. This investigation was supported by grant No. B-732, National Institute of Neurological Diseases and Blindness.
* Doris Duke fellow in neurophysiology, National Paraplegia Foundation, 1957–59.

9 January 1961

Density of the Lunar Atmosphere

Abstract. The consequences of a model are worked out in which the lunar atmosphere is formed by gravitational accretion of interplanetary gas. Our results differ from those of Firsoff and of Brandt, partly because of the inapplicability of the barometric equation to the case of an exosphere.

The density of the lunar atmosphere has been recently discussed by Firsoff (*1*) and by Brandt (*2*) from the following point of view. It is assumed that no gas is exhaled from the moon itself and that any atmosphere observed in the vicinity of the moon is produced by gravitational accretion from the interplanetary gas.

It may well be true that the amount of gas evolved from the moon is negligible, although this is by no means sure. For example, the careful work of Edwards and Borst (*3*) on the evolution of krypton and xenon must be considered, and the fate of the evolved gas has to be discussed. [We have done this in a separate paper (*4*) and conclude that the loss of krypton and xenon is quite rapid because of photoionization effects, so that its contribution to the atmosphere cannot be important.] Furthermore, the purely gravitational treatment (*1*, *2*) may not at all correspond to the real situation. Not only has the existence of a magnetic field been neglected, but we must also take into account the possible existence of a lunar electric charge, and therefore of a surface electric field. When these factors are considered, the picture changes signficantly (*4*).

However, even the purely gravitational treatment is seriously in error. This may be seen as follows. The concept of an isothermal atmosphere in hydrostatic equilibrium is invalid for an exosphere, since the mean free path exceeds the scale height and, in the present case, even the radius of the moon. Hence, the use of the so-called barometric formula, Eq. 1 in Brandt's paper (*2*), cannot be justified. The reasons for this have been discussed in detail (*5*) and are essentially concerned with the negligible effects of collisions among the gas atoms. For example, for the extreme cases considered by Brandt, it can be shown that the mean free path is from 2.5×10^9 cm ($N_\infty = 10^4$, $T = 10^4$) to 2.5×10^{11} cm ($N_\infty = 10^3$, $T = 10^5$) for protons in a plasma, and from 5×10^9 cm ($N = 10^6$) to 5×10^{11} cm ($N = 10^3$) for neutral molecules. These figures are in excess of the radius of the moon.

In the absence of magnetic and electric fields, the correct distribution of a gravitationally accreted atmosphere around a center of force, when the mean length of path exceeds the radius of the planet, can be calculated after the theory developed by Öpik (*6*) as follows:

$$N(r)/N(\infty) = 2\pi^{-\frac{1}{2}} [Y^{\frac{1}{2}} + (\exp Y) \cdot \int_Y^\infty \exp(-x^2) \cdot dx] \quad (1)$$

where

$$Y = GMM/(rkT) \quad (2)$$

We use here the notation of Brandt's paper (*2*), with $N(\infty)$ denoting the number density of the unperturbed background (interplanetary gas). When the temperature is high, or when Y is small, the difference between Brandt's Eq. 1 and our Eq. 1 is not significant. For large values of Y, however, Brandt's Eq. 1 yields the spurious high concentrations as actually calculated by Firsoff.

Even within the limited frame considered by Brandt and Firsoff, our Eq. 1 gives only the contribution to the density from interplanetary gas that is elastically scattered by the lunar surface. We may expect, however, that interplanetary protons, after striking the surface of the moon, will be accommodated (*7*). They will lose their charge and, when leaving the surface as neutral

atoms or molecules, will have a much lower temperature, greater molecular weight (*8*), and hence a larger value of Y than the incoming gas. In this respect at least, Brandt's more recent criticism (*9*) of Firsoff's work is unjustified. As has been pointed out by Gold (*10*), it is the component accommodated to the lunar surface temperature which contributes chiefly to the atmospheric density near the surface.

To calculate then the complete density distribution near the moon, one-half of Eq. 1, referring to the *incoming* component of the interplanetary gas, must be added to the density contributions from the usual components of a planetary exosphere, namely, the ballistic re-entry component and the escaping component (*5*). For these we have derived the following expression:

$$[N(r)/N_\circ]\,(r/R)^3 = \int_0^{\pi/2} \frac{\sin\theta\cos\theta\ \exp(-Ea^2)\ d\theta}{(1-y^2\sin^2\theta)^{\frac{1}{2}}} \cdot [(1+2a^2E)\phi - b\phi'] + \tfrac{1}{2}\int_0^{\pi/2} \frac{\sin\theta\cos\theta\ \exp(-Ea^2)\ d\theta}{(1-y^2\sin^2\theta)^{\frac{1}{2}}} \cdot [(1+2a^2E)(1-\phi) + b\phi'] \qquad (3)$$

where $y = R/r$, $E = GMM/(RkT)$, $a = [(1-y)/(1-y^2\sin^2\theta)]^{\frac{1}{2}}$, $b = E^{\frac{1}{2}}(1-a^2)^{\frac{1}{2}}$, and $\phi = \phi(b)$ is the error integral, $\phi'(b)$ its derivative, θ the zenith angle of the particle as it leaves the reference level R. The first integral gives the ballistic re-entry component (which contributes twice, on the way up and on the way down); the second integral gives the contribution of the escaping component. It should be noted that in this formula T refers to lunar surface temperature (*11*). The normalization for $N_\circ$ must be such that the incoming flux of interplanetary gas equals the escaping flux; it must be applied separately to each atomic species contained in the interplanetary gas. This escaping flux is given by

$$4\pi R^2 N_\circ (kT/2\pi M)^{\frac{1}{2}}\,(1+E)\,\exp(-E) \qquad (4)$$

and must equal the accreted flux

$$\pi R^2 N(\infty)(8kT/\pi M)^{\frac{1}{2}}\ (1+E) \qquad (5)$$

On account of the higher Y value of the outgoing component, the density concentration will be much greater than that calculated by Brandt. This increase will be especially pronounced for a gas component of high atomic weight, as has already been surmised by Firsoff (*12*). (Unfortunately, no quantitative statements can be made as to its abundance.) In general, however, the density will be smaller than that found by Firsoff because of the invalidity of the hydrostatic equilibrium formula which he uses. Furthermore, the density of interplanetary gas turns out to be very much lower than 10^3 cm^{-3}, as follows from recent spectral studies of the zodiacal light by the Cambridge, England, group (*13*).

Further, it may be quite unrealistic to consider a quiescent interplanetary gas cloud with respect to the moon. Because of the relative orbital motion, the effective "temperature" to be used in Eq. 1 for the incoming component must be very high, and the resulting *concentration*, accordingly, small. The accommodated component given in Eq. 3 will not be much affected, however, since it depends on the accreted *flux* and the temperature of the lunar surface (*14*).

E. J. Öpik
S. F. Singer
Department of Physics, University of Maryland, College Park

References and Notes

1. V. A. Firsoff, *Science* **130**, 1337 (1959).
2. J. C. Brandt, *ibid.* **131**, 1606 (1960).
3. W. F. Edwards and L. B. Borst, *ibid.* **127**, 325 (1958).
4. E. J. Öpik and S. F. Singer, *J. Geophys. Research* **65**, 3065 (1960).
5. ———, *Phys. Fluids* **2**, 653 (1959); **3**, 486 (1960); **4**, 221 (1961).
6. E. J. Öpik, unpublished lectures, University of Maryland, January 1960.
7. The accommodation coefficient κ depends upon the kinetic energy of the protons, relative to the moving lunar surface. κ will be close to unity for the very high temperatures quoted for the interplanetary gas (*2*). Because of the presumed porosity of the lunar surface, κ will be large even at much lower temperatures.
8. Actually, it is not molecular weight, as used by Brandt (*2*), but "effective gravitational constant" which is halved for the ions of a plasma. Hence, in Eq. 2 we use $\frac{1}{2}G$ for protons and the full value of G for hydrogen atoms.
9. J. C. Brandt, *Science* **131**, 1671 (1960).
10. T. Gold, *J. Geophys. Research* **64**, 1798 (1959).
11. It is easily seen that Eq. 3 normalizes to unity at $y = 1$, provided we add an imaginary incoming component which is equal to the escaping component.
12. V. A. Firsoff, *Science* **131**, 1669 (1960).
13. D. E. Blackwell, verbal communication at the National Academy of Sciences, 27 April 1960.
14. This work was supported by a grant from the National Aeronautics and Space Administration.

17 June 1960

Rare Tumor in Coast Redwood, Sequoia sempervirens

Abstract. A rare tumor on a conifer, *Sequoia sempervirens*, is described as it appears *in situ* and in section. Evidence is given which indicates, but does not prove, that the tumor had a developmental origin.

The infrequent occurrence of idiopathic tumors in gymnosperms makes the discovery of such abnormal growths in these ancient plants a matter of interest and significance. The significance of such a neoplasm to cancer research will be enhanced, of course, provided that the tumor possesses a primordial state of differentiation arising from aberrant embryological and genetic mechanisms. Examples of this type were reported in two species of spruce (*Picea*) (*1*). These cases were characterized by massive, subglobose growths upon the trunks, branches, and roots; a causal organism was not isolable.

Only two reports concerning tumors in *Sequoia* are known to me. The first account (*2*) described a tumor in *S. sempervirens* growing in Eastbourne, England. This tumor, of unknown etiology, caused severe galling at the base of the tree and resulted in extensive defoliation. In the second instance, Martin described tumors upon *S. giganteum* (growing in Germany) which occurred characteristically at the ground level of the young trees (*3*). He assigned the cause to bacterial infection. [A third instance of tumors in *S. sempervirens* is described by Dufrénoy (*4*).]

The present report describes the occurrence of multiple, tumorous growths upon a single specimen of the coast redwood. This tree, shown in Fig. 1*a*, is growing upon the campus of the University of California in Berkeley. Its trunk is about 35 cm in diameter and 30 m in height. The foliage is of normal appearance during the growing season, but unlike the normal sequoia tree, the needles become yellowish and even chlorotic during the late summer and winter (August to March). As in most redwoods, burls [mycorhizal? (*5*)] occur beneath the ground level.

The limbs of this tree are heavily laden with tumors which are as large as 15 cm in diameter. Curiously, these tumors are found only upon the upper parts of the limbs, and, therefore, the growths do not become pendulous. The youngest tumors are asymmetrical and smooth, but with slight swellings of light-green color; buds or shoots are never found upon the tumor surfaces. Older tumors have erupted, scaly surfaces as shown in Fig. 1*b*.

The point of attachment of the tumor is always obscured by the soft mass of tissue forming its main bulk. Nevertheless, careful removal of this soft tissue reveals that the tumor would be entirely separate from its "host" but for a slim peduncle of woody tissue (Fig. 1*c* and *e*). Thus, the latter serves as the sole physiological connection with the tree itself, and this constriction probably accounts for the fact that almost all tumors in excess of 5 cm are dead or partially necrotic. Most tumors (if not all) seem to originate immediately adjacent to a bud or a tiny branch, and, although no tumor occurred upon the trunk itself, tumors were common upon the surfaces of all the branches from their tips to their points of insertion.

Freehand sections of these neoplasms

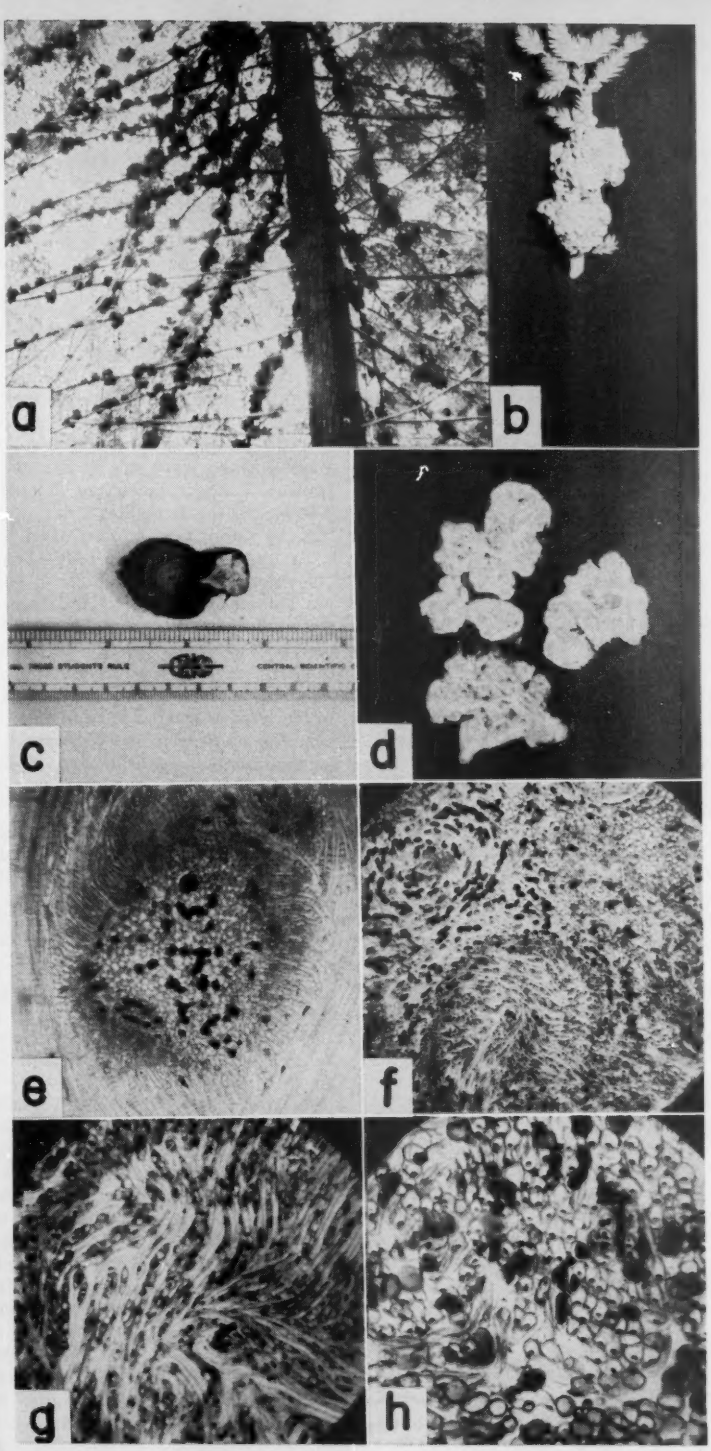


Fig. 1. *Sequoia* tumors *in situ* and in section. (*a*) Growth habit of tumors. (*b*) Typical erupted surfaces of the older tumors. (*c*) Unstained cross section of young tumor and limb showing tracheid bundle emerging from pith. (*d*) Unstained freehand sections of growing tumors. Note disorganized tissue. (*e*) Unstained, transverse section of tracheid bundle leading to tumor. Section was made just beneath cambium layer tangential to limb surface (about × 100). (*f*) Typical appearance of whole tumor after fixation in Craf III and staining with iron hematoxylin (× 50). (*g*) Immature tracheids typical of woody parts of tumor, fixed and stained as in (*f*) (× 128). (*h*) Typical disorganized, soft parenchyma fixed and stained as in (*f*) (× 128).

revealed the extensive disorganization of the tissues both in their soft and woody parts (Fig. 1*d*). Histological examination presented areas (whorls) of immature tracheids (Fig. 1*f* and *g*) surrounded by thick masses of spongy tissue and overlain by scattered areas of collenchyma. The bordered pits characteristic of sequoia tracheids were occasionally to be found. Wood rays were never observed. Figure 1*h* demonstrates the typical disorganized state of the soft tissue. In these sections empty lacunae were very common (often easily visible without magnification). Cells containing pigment (tannin?) were abundant, whereas cells with mitotic figures were very rare (*6*).

The freshly sawn surfaces of tumors dried from the living state have a very pleasant fragrance unlike that of normal wood. The latter, as is well known, is nearly odorless.

The sequoia tumors were observed by me for several years and have been noticed by campus gardeners for much longer periods. Despite the fact that several mature sequoia trees grow in such close proximity to the afflicted tree that their limbs intermingle, not one instance of abnormal growth was found upon the surrounding trees. In my opinion, these facts constitute presumptive evidence that the tumors do not have a fungal or bacterial origin—a conjecture that requires experimental confirmation. However, further support for this opinion is provided when the relationship between the tumor and its supporting tissue is examined (see Fig. 1*c*). Clearly, the tracheid bundle emanating from the pith and the narrow point of attachment of the tumor to the limb surface indicate that this abnormal growth had an early origin from a bud (Fig. 1*e* presents a cross section of the peduncle just beneath its point of insertion into the limb surface). Pertinent to this argument was the fact that freehand sections of dozens of small, growing tumors failed to disclose one instance of an insect parasite—a frequent cause of galling in many plants. Several preliminary attempts to transplant this tumor to the cambium layer of normal sequoia trees have not resulted in growth of the transplant.

It is tentatively indicated that this excrescent neoplasm does not have a parasitic origin, that it is not invasive or naturally transmissible, and that the demands upon its "host" are fastidious. The conclusion that it has a developmental origin (or genetic one) seems inescapable. In any case, one must question whether such a tumor can be considered as an entity separate from the "normal" tree upon which it grows.

C. F. EMANUEL*

Department of Physiology,
University of California, Berkeley

References and Notes

1. D. de Torok and P. R. White, *Science* **131**, 730 (1960); P. R. White and W. F. Millington, *Cancer Research* **14**, 128 (1954).
2. R. A. Bull, *Gardeners' Chronicle* **130**, 3376 (1951); *Forest Abstr.* **13**, 418 (1952).
3. E. I. Martin, *Phytopathol. Z.* **30**, 342 (1957).
4. A report by Dufrénoy [*Bull. soc. pathol. vég. France* **9**, 148 (1922)], inaccessible to me, describes another instance of tumors on *S. sempervirens*.
5. J. L. Harley, in *The Biology of Mycorrhiza*, N. Polunin, Ed. (Hill, London, 1959); N. Ferreira dos Santos, *Forest Abstr.* **6**, 7 (1944).
6. Tissues used in this study were collected during the summer months and may not be representative of the growth phase. It is probable that the growth rate is severely restricted because of the narrow peduncle described above. Therefore, the tumor is self-limiting and nonlethal.

* Present address: San Juan Research Laboratory, Bellevue, Wash.

27 December 1960

Alternation as Function of Preliminary Training and Type of Deprivation

Abstract. Laboratory rats trained upon a table top with randomly positioned reinforcement containers showed significantly a greater tendency to alternate in a Y-maze than animals trained on a straight runway. The type of deprivation, either food or water, did not have an effect. The differences in alternation disappeared with repeated trials on the Y-maze.

Alternation has attracted interest among behavioral scientists because of the observed tendency of many organisms to make a different choice on one trial of a series than that made on the preceding trial even though the two choices appeared to require the same degree of effort and to be equally rewarding. Previous studies (*1*) have shown that alternation appears in a variety of similar experimental situations —for example, human beings guessing the outcomes of coin tossing (*2*)—and that there is a persistent tendency to alternate even though one of the choices may be continuously reinforced (*3*).

Explanations of alternation have tended to consist of postulating that the organism has an attribute with properties necessary to account for the observed results. For example, reactive inhibition (*4*) has been a favorite explanation because it has been postulated that reactive inhibition is generated as a positive function of effort and dissipates with time. Presumably responses requiring a greater degree of effort would generate more reactive inhibition with a consequent greater tendency to avoid response repetition temporarily. However, experiments which have separated the degree of effort required to make a response from the time required to make the response have not supported the hypothesis that effort is a variable determining alternation.

Another type of construct links the process producing alternation to perception rather than to responses by postulating a perception-produced decrement in the perceptual process, for example, "stimulus satiation" (*1*). Such response-inferred constructs, however, tend to be circular unless the variables which control them are delineated, in which case they are redundant. An alternative approach, which has not been seriously attempted (*3*), is to examine the extent to which alternation is an effect dependent upon transfer of training. For example, rats in their laboratory living quarters may have to move around to find food; consequently, when a piece of food is consumed in one place, the animals learn to look elsewhere for other pieces.

Conceivably, similar but more complex explanations can be invoked to account for the avoidance by human beings of recently made responses. In fact, a learning explanation of the human tendency to avoid repeating guesses seems to be more plausible than an explanation involving perceptual decrement.

To test the hypothesis that alternation behavior is learned, 38 experimentally naive hooded rats, from the colony maintained at Indiana University by the psychology department, were run in a two-variable factorial design. At the start of each experimental and training session each animal was under 18-hour food or water deprivation. The animals all received 13 days of preliminary training. For 20 of the animals the preliminary training consisted of six reinforced—that is, rewarded with food or water—runs a day on a 4-foot straight runway. Each of the other 18 animals was placed for 3 minutes a day upon a 2½- by 4-foot table top on which were six randomly positioned reinforcement containers with either food or water. No animal failed to find and consume the reinforcements within the 3-minute period. The food reward was a pellet of commercial rat food weighing 45 mg. The water reward was two drops of water from a standard medicine dropper. The reinforcements were presented in small depressions drilled in 1½-inch-square aluminum pieces cut from 3/16-inch stock.

After preliminary training the animals were tested for 15 consecutive days on a Y-maze with 2-foot legs. Each animal was given two pairs of reinforced runs a day. Each pair of runs was separated by the time required to run the other animals in the group receiving the same treatment conditions. An alternation was counted if, on the second run of a pair, an animal chose the side opposite to the side chosen on the first run of the pair.

Because there is less tendency to alternate with longer time between trials (*1*), a time score based on running time in the second run of each pair of runs was computed for each animal. It might be expected that the faster animals would alternate more because they would have a shorter interval between the first and second runs of each pair. Analysis indicates that the running time for the animals trained on the straight runway was significantly shorter ($p < .01$) than that for the animals trained on the table top. The average times were, respectively, 9.99 and 15.05 seconds. If alternation depended only on the time between choices, the animals trained on the straight runway would be expected to alternate more than the others. It was found, however, that the animals trained on the table top alternated significantly more than those trained on the straight runway ($p < .05$). The type

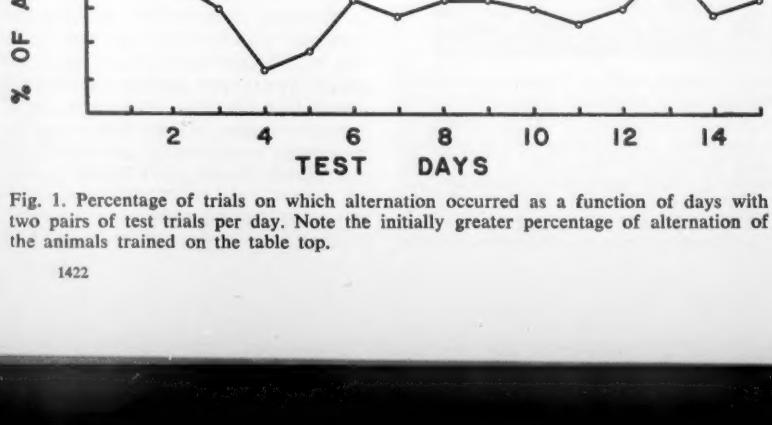


Fig. 1. Percentage of trials on which alternation occurred as a function of days with two pairs of test trials per day. Note the initially greater percentage of alternation of the animals trained on the table top.

of deprivation did not have a significant effect; therefore, the data for the animals deprived of food and water were combined (Fig. 1). A feature of the data is that the animals trained on the table top exhibit a relatively high percentage of alternation at the outset, but alternate progressively less with trials. We interpret these results to mean that the effects of preliminary training were temporary (*5*).

SIDNEY HELLYER
Defence Research Board of Canada, Defence Research Medical Laboratories, Toronto, Ontario

JAMES H. STRAUGHAN
Psychology Department, University of Oregon, Eugene

References and Notes

1. W. N. Dember and H. Fowler, *Psychol. Bull.* **55**, 412 (1958).
2. B. F. Skinner, *J. Exptl. Psychol.* **30**, 495 (1942).
3. W. K. Estes and M. S. Schoeffler, *J. Comp. and Physiol. Psychol.* **48**, 357 (1955).
4. R. L. Solomon, *Psychol. Bull.* **45**, 1 (1948).
5. The data for this report were gathered while we were graduate students at Indiana University.

3 January 1961

Electron Microscopy and Autoradiography

Abstract. The combined techniques of electron microscopy and autoradiography were used for the purpose of differentiating radioactive from nonradioactive particles collected on membrane filters. Newer methods of processing the membrane filters and applying the nuclear emulsion have resulted in an improvement in the qualitative nature of the procedure.

A method for differentiation of radioactive and nonradioactive particles collected on membrane filters and examined with the electron microscope was reported in an earlier paper (*1*). Continual application of this method during the past year has resulted in a number of refinements and the development of a reliable and reproducible method for processing membrane filters used in the sampling of radioactive aerosols. The objective of the present report is to describe in detail the method of processing membrane filters for examination with the electron microscope, and to discuss those modifications of the technique which have improved its qualitative nature.

Previous workers have reported on application of the combined techniques of electron microscopy and autoradiography for various purposes (*2*). The technique described in the present report was developed for the purpose of obtaining a more accurate analysis of aerosols that contain radioactive particles. The aerosols in this particular case were used in a study on the effects of the inhalated radioactive particles. The same technique could be applied to a number of other studies involving the collection and analysis of air samples containing or potentially containing radioactive particles. Application of the present technique is limited to alpha-emitting particles. Further studies are presently being conducted to test its usefulness for beta-emitting particles.

In the technique under discussion, membrane filters (type AA; plain, Millipore Filter Corp., Bedford, Mass., 25-mm diameter), which are an integral part of closed chambers used to expose the lungs of animals to radioactive dusts, are processed for examination with the electron microscope in the following manner. The membrane filter containing the collected aerosol sample is positioned with the collecting side upward on a 2- by 2-in. piece of Teflon. While the filter is steadied with a dissecting needle or similar instrument, a small disk is cut out of the central portion of a membrane filter with a 3-mm brass cork bore. The small disk thus cut out of the filter is placed with the collecting side down on the surface of a Formvar and carbon-coated electron microscope grid. The grid(s) thus prepared are supported in a petri dish by a mediumpore, sintered-glass filter stick beneath which are three sheets of No. 41 Whatman filter paper. The filter solvent of choice (acetone in this case) is then carefully poured into the petri dish until the filter paper is completely saturated, but not covered, by the acetone. The petri dish is then covered with its lid and allowed to stand at room temperature until the acetone has evaporated and the specimen grid has dried. This usually requires approximately 16 hours.

Dissolving the filters in this manner is a distinct departure from previous methods, and in our experience it has resulted in a more uniform distribution pattern of the collected aerosol sample. The commonly used rapid method for dissolving samples of membrane filters (*1*, *3*) resulted in loss of the smaller particles and aggregation of the larger particles on or along the grid wires. After dissolution of the membrane filter, the dried specimen grids can be examined with the electron microscope and, if desired, selected areas can be photographed. The grids with the sample side up are then secured for application of the nuclear emulsion to one end of small glass pegs 3 mm in diameter by means of double-coated Scotch tape. The pegs, with the grids in an upright position, are then inserted into holes of slightly larger diameter drilled into a block of stainless steel. The depth of the drilled holes is equal

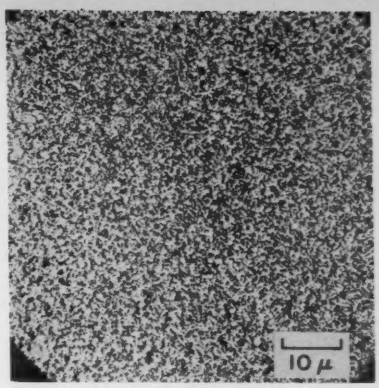


Fig. 1. Electron micrograph showing the distribution pattern of undeveloped silver grains over a specimen grid aperture.

to one-half the length of the glass pegs. All subsequent steps in the process of autoradiography are carried out in a darkroom under light filtered through a Wratten, Series OA, filter. Alpha-sensitive Eastman Kodak NTA emulsion in gel form (*4*) is heated at 45°C until fluid, and then 2 ml are diluted 1:1 with distilled water. One drop of a dilute solution (0.05 percent) of sodium lauryl sulfate is added to the diluted emulsion. In previous work the emulsion was more dilute (1:2) and the detergent was omitted. This resulted in an uneven distribution of silver grains over the specimen grid. The modification in the preparation of the emulsion has resulted in a uniform and even distribution of the silver grains over the entire specimen grid aperture. Figure 1 shows the distribution pattern of undeveloped silver grains applied by the above method.

The specimen grids secured to the glass pegs in the stainless steel block are then coated by means of a fine wire loop which is dipped into the emulsion

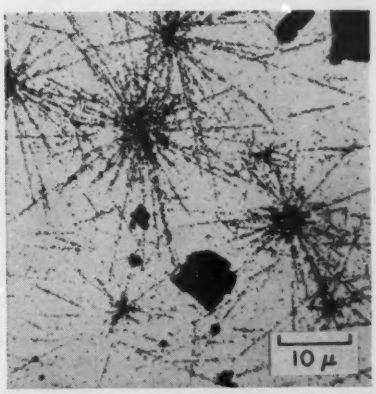


Fig. 2. Electron micrograph showing the differentiation of radioactive and nonradioactive particles.

and then slowly withdrawn, leaving a thin layer of the diluted emulsion in the loop. The emulsion is then placed on the specimen grid by passing the loop down over the stationary grid.

After coating, the secured grids are placed in a light-tight box and exposed for a suitable length of time at 4°C. With plutonium-239, the radioelement used in this study, 3 days of exposure were found to be sufficient. The autoradiograms are then developed by immersing the stainless steel block supporting the grids in Eastman Kodak D-19 developer for 5 minutes, rinsing twice in tap water, fixing in acid fixer for 15 minutes, and thoroughly rinsing in running tap water for 30 minutes. After drying, they are examined with an RCA EMU-2C electron microscope.

An example of the results obtained is shown in Fig. 2, which illustrates the differentiation of radioactive and nonradioactive particles (*5*).

L. A. GEORGE II
Biology Laboratory, Hanford Laboratories, General Electric Company, Richland, Washington

References and Notes

1. L. A. George II and G. S. Vogt, *Nature* **184**, 1474 (1959).
2. J. J. Comer and S. J. Skipper, *Science* **119**, 441 (1954); J. Liquier-Milward, *Nature* **177**, 619 (1956).
3. E. H. Kalmus, *J. Appl. Phys.* **25**, 87 (1954).
4. The emulsion was supplied through the courtesy of Eastman Kodak Co., Rochester, N.Y.
5. This work was performed under contract No. AT(45-1)-1350 between the U.S. Atomic Energy Commission and the General Electric Company.

25 November 1960

Phototropic Inversion in Phycomyces

Abstract. Transient reversed bending follows an adequate step-up in light intensity given a bending cell from any direction around its axis, yet the plane of the response is specifically that in which prior phototropic bending occurred. The cell "remembers" what it was doing and reverses this in the ensuing light-growth response. Antecedent asymmetric growth itself built the pattern for reversal.

An upright sporangiophore of *Phycomyces* exposed to a single horizontal beam of visible light responds by bending toward the light source; this is its characteristic *positive* phototropism. Bending rate, measured as the change in angle between the cell's extremity and the vertical, is nearly constant over a period of 10 to 15 minutes, and over a wide range it is independent of the intensity (*1*). This implies that the differential growth underlying bending is primarily determined by the asymmetry of the illumination pattern around the cell's axis and not by the level of light intensity.

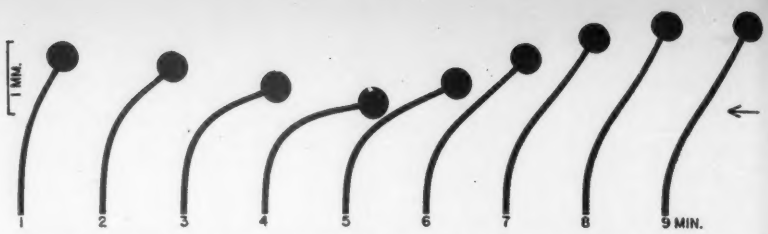


Fig. 1. Serial time-lapse photographs of *Phycomyces* showing normal bending interrupted by inversion. Abscissa, time; ordinate, vertical axis. Low intensity light source continuously illuminates cell from right (arrow); cell was straight when this commenced at –6 minutes. Normal positive bending is seen in pictures taken at 1 through 4 minutes. At 0 time the bending cell was given a 15-second flash of high intensity light from behind (perpendicular to plane of paper). Reversed bending is seen in pictures taken at 5 through 9 minutes; it takes place in the same vertical plane (that of the paper) as initial bending. Later (not shown) normal positive bending is restored.

Paradoxically, Reichardt and Varjú (*1*) showed that positive phototropic bending could be temporarily halted and reversed by a sudden sustained increase in the intensity of the horizontal stimulating beam. The established bending rate after a delay falls to zero and reverses its sign so that the cell for a time bends *away from* the light source; then this phase of *negative* phototropism ends, and the cell gradually regains its normal positive bending rate. This inversion is remarkable because it is caused simply by a properly timed increase in the intensity of the stimulating beam; the asymmetry of the illumination pattern remains unchanged.

I have studied inversion by photographic methods, previously described (*2*), that permit determination of both bending and cell elongation and have found that an acceleration of the cell's elongation rate indeed accompanies inversion. Reichardt and Varjú, however, always induced inversion by a step-up in intensity of the original stimulating beam, and their explanation assumes that an illumination pattern *within the cell* polarized in this direction and produced by the cell's lens action is necessary for inversion. This assumption is wrong. I have used a movable, supplementary light source to give the desired increase in light intensity along any chosen direction in the horizontal plane. I found that a sufficient step-up in intensity given even at right angles to the normal phototropic beam (or apparently at *any* angle to it) produces inversion (Fig. 1). So also does a 1-second flash of very high intensity light even though it is known to be phototropically ineffective and presumably saturating (*3*). Inversion is therefore caused by a step-up in light intensity *unspecific* as to both its direction and the cellular illumination pattern produced, even though the plane in which inversion occurs is *specifically* the plane of prior bending. Figuratively, the cell "remembers" what it was doing. This can only have a structural basis in the recent past history of the cell.

Growth requires supply systems and irreversibly forms the fibrils of the wall. Material so used comes from the substrate and more immediately from the cell's interior. The available local supply is the balance between rate of arrival and rate of use. I suppose that growth involves the presence of at least two materials, S and M. The supply of S is affected by light and tied to the adaptation system; M is used up in growth but is independent of light except as light affects its removal through use. Locally available M may be called growth *capacity*. The momentary rate of growth is considered proportional to the product $S \cdot M$. If more light is given, $S \cdot M$ temporarily rises, then declines in part because the growth capacity falls through the use of M. This is the light-growth response. With unilateral illumination $S \cdot M$ is kept slightly higher on the cell's far side by some consequence of the lens action. If subscripts n and f denote the near and far sides of the cell, the following conditions should apply during steady phototropic bending:

$$S_f \cdot M_f > S_n \cdot M_n$$
$$S_f > S_n$$
$$M_f < M_n$$

Thus local growth capacity, M, during steady bending is inversely related to the local growth rate, being high on the concave (near) side and low on the convex (far) side.

Such a bending cell is now given a step-up in light intensity: S rises rapidly wherever light acts and growth briefly accelerates, but then the ratio $S_f \cdot M_f / S_n \cdot M_n$ falls because M_f is now further depleted by fast growth; hence temporarily $S_n \cdot M_n$ can exceed $S_f \cdot M_f$ and *reversed* bending sets in. This is the inversion phenomenon, and it lasts until the level of M is restabilized in relation to S. The kinetics sought by Reichardt and Varjú involve the tem-

poral interplay between a light-sensitive system and a cooperating "dark" system.

The chief evidence for this interpretation lies in the cited irrelevance for inversion of the light pattern evoking it. A depletion effect is also suggested by the fact that reversed bending does not start until after 2 to 3 minutes of unusually rapid elongation; in fact, the maximum rate of reversed bending just about coincides in time with the maximum rate of elongation. Further, in studying the distribution of elemental curvature along the growth zone during bending and inversion, I found that the maximal initial rate of reversed bending occurs at or very near the locus of maximal curvature; this would be that level in the growth zone where, across the cell, the greatest accumulated difference in growth capacity exists, and where a burst of light ought to initiate the fastest reversed bending.

The spatial distribution of bending velocity changes with time in a way suggesting that capacity deficit first develops high in the growth zone because supply is basically from below (*4*). I attribute the strict polarization of reversed bending in the plane of prior curvature to the pattern of altered growth capacity established by the different growth rates during prior bending. This pattern may well involve different states of extension of the cell wall's microfibrils which are engaged in multinet growth (*5*).

Growth capacity evidently works with adaptation but overrides it under conditions where a burst of light unmasks latent capacity differences across the cell's diameter. One might choose to consider growth capacity as a normally concealed supply problem supplementary to adaptation. But operationally, adaptation is known only by what a system does: whether, how much, and in what direction it responds. Hence the scheme of Delbrück and Reichardt for the light responses of *Phycomyces* (*6*) must be judged imperfect. Its deficiency confounds Reichhardt and Varjú's analysis of inversion.

E. S. CASTLE
Biological Laboratories, Harvard University, Cambridge, Massachusetts

References

1. W. Reichardt and D. Varjú, *Z. physik. Chem. Neue Folge* **15**, 297 (1958).
2. E. S. Castle, *J. Gen. Physiol.* **41**, 913 (1958); **42**, 697 (1959).
3. ———, *Botan. Gaz.* **91**, 206 (1931).
4. A report of studies of the spatial distribution of bending velocity is in preparation.
5. P. A. Roelofsen, "The plant cell-wall," *Encyclopedia of Plant Anatomy* (Borntraeger, Berlin, 1959), vol. 3, pt. 4.
6. M. Delbrück and W. Reichardt, in *Cellular Mechanisms in Differentiation and Growth*, D. Rudnick, Ed. (Princeton Univ. Press, Princeton, N.J., 1956).

9 January 1961

Nitrogen Deficiency and Fluoride Susceptibility of Bean Seedlings

Abstract. Groups of bean seedlings (*Phaseolus vulgaris*) were grown concurrently in cleaned and fluoride-containing (4 to 7 μg of F^- per cubic meter) air in plant-growth chambers for 10 and 20 days with six water-culture treatments: Hoaglund's formulation and Hoaglund's minus potassium, calcium, nitrogen, phosphorus, and iron. An inadvertent 15-hour exposure on day 15 (at 42 $\mu g/m^3$) produced foliar fluorosis symptoms only on the nitrogen-deficient plants fumigated 20 days, although higher fluoride concentrations were present in the foliage of similar plants grown in the other nutrient-deficient solutions.

The limited published data relating nutrition levels to susceptibility or resistance of plants to atmospheric fluoride exposure appear to be somewhat paradoxical. Brennan *et al.* (*1*) studied visible fluoride-induced, foliar toxicity in tomatoes as modified by alterations in the nitrogen, calcium, and phosphorous nutrition. They concluded that medium levels of nitrogen and calcium nutrition favored sorption of toxic quantities of fluorine, whereas low or deficient nutrition levels prevented fluorine injury. Fumigation concentrations of 48 and 470 parts of hydrogen fluoride per billion were used in these experiments.

Applegate and Adams (*2*) recently reported the effect of nutritional and water deficiencies on respiration and relative fluoride uptake of bean seedlings (*Phaseolus vulgaris*) at low fumigation levels of fluoride. Ten- and twenty-day fumigations were conducted at approximately 2 μg of F^- per cubic meter (1.6 parts per billion) of hydrogen fluoride, which is well below exposure levels required to produce visible, fluoride-induced foliar necrosis. The data showed that deficiencies in potassium, phosphorus, and iron accelerated the uptake of atmospheric fluoride. Direct comparison of data was impossible because of basic differences in the experimental techniques that were used in these separate investigations (*1*, *2*).

Studies at low fumigation concentrations are continuing in this laboratory. All plants are grown in an air pollution phytotron (*3*), and the experimental techniques have been described previously (*2*). Recently, one set of beans was inadvertently exposed to a high concentration of atmospheric hydrogen fluoride. For a period of 15 hours on day 15 of a 20-day exposure, the average concentration was 42 $\mu g/m^3$ (34 parts per billion). This acute exposure produced foliar necrosis in all plants subjected to one of the six nutrient treatments being studied. This report presents some observations on the influence of nutrition upon the susceptibility of beans to visible foliar injury from atmospheric fluorides (*4*).

One-half of the 20-day fumigated and control bean plants are shown in Fig. 1. The duplicate plants (not photographed) showed similar characteristic growth patterns and foliar markings. No fluorine-induced necrosis was observed in the group of 48 plants fumigated for 10 days and removed from the phytotron prior to the accidental 15-hour exposure at 42 $\mu g/m^3$. Foliar fluorosis was observed on all eight of the plants grown in nitrogen-deficient nutrient and fumigated 20 days. No fluoride-induced foliar symptoms were

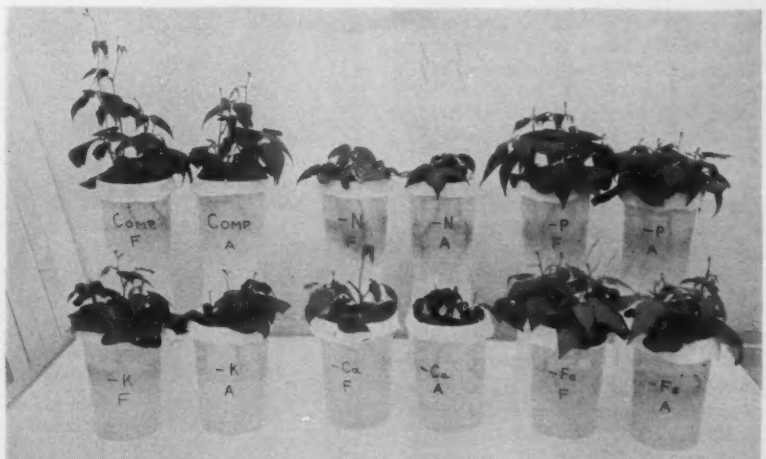


Fig. 1. Twenty-day fluoride-fumigated (F) and control (A) bean plants (*Phaseolus vulgaris*) grown in complete (Hoaglund's) nutrient solution "COMP" and nutrient solutions from which nitrogen (— N), phosphorus (— P), potassium (— K), calcium (—Ca), and iron (—Fe) have been withheld.

5 MAY 1961

present on any of the other 40 plants in the 20-day set.

The fluoride-induced foliar symptoms expressed by the plants grown in nitrogen-deficient nutrient, although typically marginal, were also interveinal in nature. Interveinal effects are frequently produced by acute fluoride fumigations (*5*). The fluoride concentration in the leaves of the plants grown in nitrogen-deficient nutrient at the onset of acute episode on the 15th day was, of course, not specifically known. However, the foliar concentrations were known to be somewhere between 211 (the 10-day concentration) and 360 parts per million (the 20-day concentration) on a dry-weight basis. The plants grown in a complete nutrient showed, by way of comparison, 183 parts of F^- per million after 10 days of fumigation and 348 parts per million after 20 days. The 10-day average fumigation concentration was 4.7 $\mu g/m^3$, and the 20-day exposure level was 6.9 $\mu g/m^3$.

It is quite significant that plants treated with formulations deficient in other nutrients, although having higher foliar fluoride concentrations (10-day foliar fluoride range, 213 to 360 parts per million; and 20-day range, 394 to 463 parts per million) than the plants grown in either the complete nutrient or in nitrogen-deficient nutrient, did not show any visible expression of foliar damage. Thus additional evidence is provided, within a single variety, that production of necrosis is not solely related to the fluoride concentration in the tissue. Fluoride susceptibility must, therefore, be biochemically associated with other metabolic processes.

Typical growth patterns and differences in fluoride response related to the absence of each of the five nutrients were readily observed. One additional characteristic growth phenomenon is obvious from Fig. 1. All plants fumigated with fluoride for 10 or 20 days exhibited a longer initial internodal growth than the control plants. This phenomenon (*6*) has been observed repeatedly in a variety of experimental exposures and conditions during the last 2 years.

Studies are being conducted to elucidate these and previously reported (*2*) nutrient-related phenomena.

D. F. ADAMS
C. W. SULZBACH
Division of Industrial Research, Washington State University, Pullman

References and Notes

1. E. G. Brennan, I. A. Leone, R. H. Daines, *Plant Physiol.* **25**, 736 (1950).
2. H. G. Applegate and D. F. Adams, *Phyton, Ann. rei botan.* **14**, 111 (1960).
3. D. F. Adams, paper to be presented at the annual meeting of the Air Pollution Control Association, New York, June 1961.
4. This study was supported by a grant-in-aid award from medical and biological research funds provided by Washington State Initiative 171.
5. M. D. Thomas and R. H. Hendricks, *Air Pollution Handbook* (McGraw-Hill, New York, 1956), sec. 9.
6. H. G. Applegate, Washington State University, unpublished information (1960).

19 December 1960

Spinal Reflexes and Seizure Patterns in the Two-Toed Sloth

Abstract. In striking contrast to the seizure patterns of other animals, the electroshock seizure of the sloth consists of weak extension followed by tonic flexion and terminal clonus. A similar pattern is seen with direct spinal cord stimulation. Strychnine produces a pure flexor convulsion. In the spinal sloth, painful stimulation of one foot causes extension at some joints of that limb and strong flexion at all joints of the contralateral limb.

The maximal seizure pattern in man and most laboratory animals consists of the sequence of tonic flexion, tonic extension, and clonus (*1*). Previous investigations in our laboratory (*2*, *3*) have shown that the final determinants of the motor patterns of seizures are the reflex systems of the spinal cord. From this finding stems the prediction that the tonic components of the seizure pattern of the sloth should be in reverse sequence to those of most laboratory animals, since in this species the most powerful limb muscles are the flexors, which serve an antigravity function. Richter and Bartemeier (*4*) have shown that the decerebrated sloth assumes a posture of flexor rigidity.

Various types of seizures were investigated in the two-toed sloth (*Choloepus hofmanni*). Of four animals obtained (*5*), only two (*1* and *2* of Fig. 1) were in satisfactory condition for investigation of seizure patterns. These sloths were each studied for a period of about 2 weeks; they ate well (citrus fruits, bananas, and green vegetables) and remained in good condition during that time.

Fifteen electroshock seizures, elicited by stimuli of varying parameters from an a-c electroshock apparatus (*6*), were observed. Current was delivered through clips attached to the eyelids. In both sloths the motor patterns following supramaximal brain stimulation (0.5 amp, 1.0 sec) consisted of weak extension (Fig. 1, *1b*), followed by rigid tonic flexion of limbs, trunk, and neck (Fig. 1, *1c*). Terminal clonus, principally of the claws and of the jaw, persisted for about 1 minute after relaxation from flexion. The seizure was followed by a period of profound postictal depression. Although the seizures produced by supramaximal brain stimulation were of identical pattern in the two sloths, the times to onset and termination of the flexor phase differed: average times from the end of brain stimulation to the beginning and to the end of flexion, were, respectively, 11 and 35 seconds for sloth 1, and 5 and 27 seconds for sloth 2.

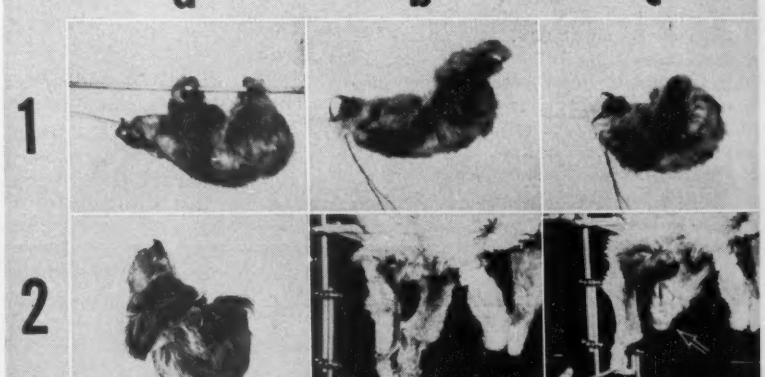


Fig. 1. Seizure patterns and reflex movements in two sloths. Sloth 1, 3.3 kg; (*a*) usual position of animal hanging on bar (restraining noose around neck); (*b*) weak extension 3 seconds after supramaximal brain stimulation; (*c*) tonic flexion 25 seconds after supramaximal brain stimulation; (*b*) and (*c*) are from a motion picture record of one convulsion. Sloth 2, 4.5 kg; (*a*) tonic flexion produced by intracardiac administration of 1 mg/kg of strychnine; (*b*) and (*c*) sloth suspended in a harness following spinal transection; (*b*) normal position hanging in harness; (*c*) reflex position assumed during pinching of right footpad. Note strong flexion of limb and claws on the left side, identified by the arrow. Extension of the foot and of the claws can be seen on the right side.

The phase which precedes tonic flexion appears to be weak extension; however, there was little extensor tone, and the limbs could be manually flexed. That this phase represents a decrease in normal flexor tone is demonstrated by the fact that the animal lost its grasp if the shock was applied while it was hanging on a bar.

In seizures elicited with submaximal current, or in seizures elicited with supramaximal current during the period of postictal depression, tonic flexion was absent or greatly reduced. Thus, decrease in flexion in the sloth parallels the decrease in tonic extension seen in other animals under such circumstances (*1*).

Intracardiac injection of strychnine (1 mg/kg) rapidly produced a pure tonic flexor convulsion (Fig. 1, *2a*). This seizure is in contrast to the strychnine convulsions in most animals in which pure extension is seen. In a more fundamental sense, however, the strychnine seizure of the sloth is comparable to that seen in other animals in that the pattern of the seizure is determined solely by the most powerful muscles. Administration of pentobarbital (35 mg/kg) produced relaxation from tonic flexion and caused the appearance of flexor jerks.

Four days after the strychnine convulsion, the spinal cord was transected at the atlanto-occipital junction, and the cord was electrically stimulated by means of a needle inserted in the cord from about C_1 to C_4. The technique employed has been described previously (*3*). Spinal cord stimulation duplicated all the motor patterns seen during electroshock convulsions in the intact sloth. Single stimuli produced flexor thrusts. Stimulation at frequencies of 2 to 6 pulses per second resulted in alternating hindlimb movements which resembled the normal (upside-down) mode of locomotion of the sloth. Walking movements also are seen in the spinal cat over this frequency range (*3*). High-frequency stimulation (100 to 300 pulses per second) produced convulsions which contained all the components of the seizure produced by supramaximal brain stimulation. At a frequency of 300 pulses per second the onset of the flexor phase was at 4 seconds in sloth 2, only slightly less than the time to onset of flexion in the maximal electroshock seizure in this animal.

After spinal cord section in sloth 2, and just prior to cord stimulation, various reflexes of the hindlimbs were examined. Tapping the superficial tendons, the majority of which subserve flexor muscles, elicited brisk stretch reflexes. The most unusual reflex observed in this spinal sloth was that associated with painful stimulation of the footpad. In species previously investigated (*7*), this reflex consists of withdrawal of the limb to which the painful stimulus is applied and extension of the opposite limb. In the sloth the response to pinching of the footpad is strong flexion of all joints in the contralateral limb (Fig. 1, *2c*). Slight flexion at the knee and marked extension of the foot and claws are observed on the side stimulated. While this reflex is opposite in direction to that which has been observed in other animals, it would appear to serve the same functions during normal locomotion, namely, to avoid the painful stimulus with one limb and to support the body with the opposite limb (*8*).

DON W. ESPLIN
DIXON M. WOODBURY
Department of Pharmacology, University of Utah College of Medicine, Salt Lake City

References and Notes

1. J. E. P. Toman, E. A. Swinyard, L. S. Goodman, *J. Neurophysiol.* **9**, 231 (1946).
2. D. W. Esplin and R. J. Laffan, *Arch. intern. pharmacodynamie* **113**, 189 (1957).
3. D. W. Esplin, *Arch. Neurol. Chicago* **1**, 485 (1959); D. W. Esplin and J. W. Freston, *J. Pharmacol. Exptl. Therap.* **130**, 68 (1960).
4. C. P. Richter and L. H. Bartemeier, *Brain* **49**, 207 (1926).
5. The animals were obtained from Ray Singleton, collector and distributor of wild animals, Rattlesnake, Fla.
6. L. A. Woodbury and V. D. Davenport, *Arch. intern. pharmacodynamie* **92**, 97 (1952).
7. C. C. Hunt and E. R. Perl, *Physiol. Revs.* **40**, 538 (1960).
8. This work was supported by a senior research fellowship (SF-145) and grants (B-872 and B-381) from the National Institutes of Health, U.S. Public Health Service, and by the National Neurological Research Foundation.

20 December 1960

Haptoglobin Types in Poland

Abstract. The frequency of the Hp^1 gene in Polish subjects is 0.36. This frequency is lower than that in Western European populations and higher than that in Asiatic populations. We suggest that the increase in frequency of this gene from East to West has a regular continuous character that may be attributed to a still-unclear genetic mechanism.

Distribution in different populations of the haptoglobin types and the genes controlling their inheritance is of great anthropological interest. The frequency of the Hp^1 gene is high among African Negroes and low among Asiatic people; in European populations so far tested it ranges from 0.34 to 0.47 (the reported data are collected in the paper of Sutton *et al.*, *1*). Up to now no data have been available for any of the Slavonic populations. The present report gives the results of haptoglobin type determinations of 208 Polish subjects (unselected blood donors from Warsaw).

Table 1. Haptoglobin types in 208 Polish subjects.

Haptoglobin type	Sex (No.)		Total (No.)
	M	F	
1–1	21	2	23
2–1	75	29	104
2–2	55	26	81
Total	151	57	208

Sera containing 300 mg of hemoglobin per 100 ml were assayed by vertical starch gel electrophoresis (*2*) with subsequent staining of gels with *o*-tolidine (*3*). The results obtained are shown in Table 1. Ahaptoglobinemia was not found in any case. The Hp^1 frequency computed from these data was 0.3606.

The Polish population is characterized by a relatively low frequency of Hp^1 allele which is lower than that found in Western European populations (*1*) and close to those occurring in Norwegian (*4*) and Finnish (*5*) populations; the distribution of all three haptoglobin types in these populations is statistically indistinguishable (as proved with the chi-square test). However, haptoglobin type 1-1 occurs in 11.1 percent of Poles, 13.2 percent of Norwegians, and 14.5 percent of Finns; haptoglobin type 2-2 occurs in 38.9, 40.6, and 42.0 percent, respectively. This might correspond to a regular lowering of the Hp^1 gene frequency from the west to the east of Europe—where the only exceptions are found in some parts of Italy (*6*) and Germany (*7*)—and might be due to a historically earlier mixing of haptoglobin genes in the Polish population or to other genetic mechanisms. More detailed study of the distribution of haptoglobin types is needed to clear up this problem.

K. MURAWSKI
T. MISZCZAK
Department of Biochemistry, Institute of Hematology, Warsaw, Poland

References and Notes

1. H. E. Sutton, G. A. Matson, A. R. Robinson, R. W. Koucky, *Am. J. Human Genet.* **12**, 338 (1960).
2. O. Smithies, *Biochem. J.* **71**, 585 (1959).
3. J. A. Owen, H. J. Silberman, C. Got, *Nature* **182**, 1373 (1958).
4. E. A. Fleischer and J. Lundevall, *Proc. Sixth Congr. Hematol.* (Karger, Basel, 1958), p. 906.
5. O. Mäkelä, A. W. Eriksson, R. Lehtovaara, *Acta Genet. et Statist. Med.* **9**, 149 (1959).
6. H. Harris, E. B. Robson, M. Siniscalco, in *Symposium on Biochemistry of Human Genetics*, G. E. W. Wolstenholme and C. M. O'Connor, Eds. (Churchill, London, 1960), p. 151.
7. H. Baitsch, G. Meier, L. Schoeller, D. M. Kahlich-Koenner, *Nature* **186**, 976 (1960); O. Serfas and G. Schubert, *Blut* **6**, 304 (1960).

29 November 1960

Recovery from Electroconvulsive Shock as a Function of Infantile Stimulation

Abstract. Eighty Wistar rats were handled at 2 to 5, 6 to 9, or 10 to 13 days of age, or not at all. In adulthood each group was split into halves with one-half of each group receiving electroconvulsive shock treatment. Assays of sugar concentration in the blood serum 24 hours after the convulsions indicated that subjects handled at 2 to 5 days of life exhibited no effect of the treatment, whereas all other groups showed marked increases in blood sugar concentration.

Several studies of critical periods in infancy have been made recently (*1*). On the behavioral level, Karas (*2*) found that rats handled during the first 10 days of life were better avoidance learners in adulthood than rats handled during the second 10 or first 20 days of life. Denenberg and Bell (*3*) demonstrated that mice handled and shocked at 2 to 3, 8 to 9, or 15 to 16 days of age displayed markedly different patterns of learning an avoidance response in adulthood; these differences also varied as a function of the intensity of the unconditioned stimulus used in the avoidance conditioning.

Investigating the physiological effects of handling during infancy, Levine and Lewis (*4*) have determined that rats handled at ages 2 to 5 or 2 to 13 days exhibit significant adrenal ascorbic acid depletion when assayed at 14 days, but that animals handled at 6 to 9 or 10 to 13 days do not show evidence of depletion. Observing that handled rats, when observed in an open field, show less defecation, urination, crouching, and wall-seeking behavior than nonstimulated rats (*5*), Levine has hypothesized that stimulation during the first 5 days of life accelerates the maturation of the "stress response" and that stimulated animals persist in being less reactive to stresses imposed later in life (*6*).

Both Denenberg and Karas (*7*) and Levine and Otis (*8*) have demonstrated significantly lower mortality rates after total food and water deprivation for stimulated rats than for nonstimulated rats. Further, adrenal hypertrophy was significantly greater in nonstimulated animals 24 hours after an injection of hypertonic glucose (*9*). However, an investigation of the effects of infantile stimulation on circulating adrenal steroids after electric shock to the feet in adulthood showed that stimulated animals showed a more rapid rise in corticesterone output and a consistently greater production of steroids for a 15-minute period after 1 minute of shock than nonstimulated animals did (*6*). This last finding casts considerable doubt upon the previously mentioned hypothesis and suggests that, rather than being less reactive, the stimulated animals are hyperactive to stress. However, the steroid values were computed only for the first 15 minutes after the shock, and Levine (*6*) has suggested that investigations of the long-term reaction to the shock might reveal that the stimulated animals show a greater immediate reaction, but possibly recover more rapidly, than nonstimulated animals. The present study reports some of the results of such an investigation.

The subjects were 80 Wistar strain albino rats which were handled daily from 2 to 5 days, 6 to 9 days, or 10 to 13 days, or not at all. Handling consisted of removing the complete litter from the home cage and placing the pups in a sawdust tray. After 3 minutes the pups were returned to their home cage. All litters were weaned at 21 days of age and reared thereafter in small cages with litter mates. At 46 days of age the four groups were split into halves. One-half of each group was subjected to a series of electric shocks by means of snap-on ear electrodes. Intensity of shock was systematically increased until a convulsion was produced, after which the rats were returned to their cages. At 47 days of age all subjects, both shocked and nonshocked, were anesthetized with ether, the wall of the right ventricle of the heart was punctured with a syringe, and a sample of blood was removed, after which the subjects were killed. A protein-free blood filtrate was prepared (*10*), and glucose concentration was analyzed by means of the Folin-Wu method (*11*).

Analyses of variances of the number and intensity of shocks required to produce a convulsion showed no significant differences between the groups. It may therefore be concluded that the handling of the rats at different ages during infancy did not differentially affect their resistance to electroconvulsive shock, and that the shock treatment was essentially identical for all groups.

Figure 1 presents the mean differences in blood sugar concentration between the shocked and nonshocked rats for each of the handled groups and the controls. These differences represent the effect of the convulsions 24 hours after they were induced.

An analysis of the mean differences indicates that those subjects handled during the first 5 days of life showed no significant differences in blood sugar concentration between the shocked and nonshocked subjects. Those subjects not handled during infancy and those subjects handled only after the first 5 days of life showed significantly higher concentrations of blood sugar for the shocked animals as compared to the nonshocked ones ($P = .01$).

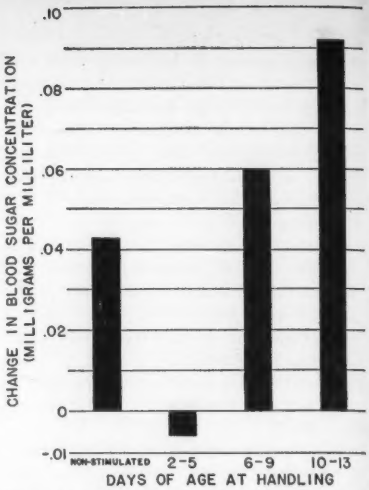


Fig. 1. Mean differences in blood sugar concentration 24 hours after electroconvulsive shock as a function of age at which handled.

The present data, when combined with the findings reported by Levine (*6*), tend to support the hypothesis that handling rats during the first 5 days of life produces an animal which tends to show an immediate and marked reaction to stress, with a complete recovery within 24 hours. This is in contrast to the reaction to stress presented by nonhandled rats and those handled only after the first 5 days of life who tend to be hyporeactors and show no signs of recovery 24 hours after the stress. The present data are identical in pattern to Levine and Lewis's (*4*) results with ascorbic acid depletion; they demonstrate that the adult pattern is the same as that found in infancy.

ROBERT W. BELL
GERALD REISNER
THEODORE LINN

Allegheny College, Meadville, Pennsylvania

References

1. J. A. King, *Psychol. Bull.* **55**, 46 (1958).
2. G. G. Karas, thesis, Purdue University (1958).
3. V. H. Denenberg and R. W. Bell, *Science* **131**, 227 (1960).
4. S. Levine and G. W. Lewis, *ibid.* **129**, 42 (1959).
5. S. Levine, *Can. J. Psychol.* **13**, 243 (1959).
6. ———, paper presented at the 1959 Chicago meeting of the AAAS.
7. V. H. Denenberg and G. G. Karas, *Science* **130**, 629 (1959).
8. S. Levine and L. S. Otis, *Can. J. Psychol.* **12**, 103 (1958).
9. S. Levine, *Science* **126**, 405 (1957).
10. P. B. Hawk, *Practical Physiological Chemistry* (1887), p. 416.
11. Folin-Wu, *J. Biol. Chem.* **41**, 367 (1920).

28 December 1960

Association Affairs

The Third Denver Meeting: Some Background

This year's annual meeting of the AAAS will be held in Denver, Colorado, from 26 to 31 December. It will be the third Denver meeting; the earlier meetings were held as long ago as August 1901 and June 1937, respectively. Members of the Southwestern and Rocky Mountain Division of the AAAS long have wanted their fellow members to revisit this unique city, a mile above sea level, set against a mighty backdrop of snow-capped mountains. Completion last year of the new Denver Hilton Hotel and of the Brown Palace Annex now makes this possible.

Denver is the administrative, financial, commercial, and industrial center of the Rocky Mountain region. There is no other large city within 500 miles in any direction. In recent years it has become a scientific center as well. The Federal Center and other buildings house well over 100 administrative offices of the U.S. Government, including the mint. Many of these agencies have large scientific staffs; for example, it is said that there are more geologists around Denver than in Washington, D.C. The principal field station of the National Bureau of Standards, with extensive radio and cryogenic laboratories, is located at nearby Boulder.

Virtually all of Colorado's large educational institutions are in the Denver area or within easy driving distance. For instance, the University of Colorado (17,903 students) at Boulder is about 25 miles to the northwest. There is an express highway to Boulder, and buses leave at frequent intervals. The university is greatly expanding its research facilities. The High Altitude Observatory at Climax, Colorado, widely known since 1940 for solar and cosmic observations, now has its new central laboratory and administrative offices on the campus. A nuclear-physics laboratory and cyclotron are scheduled for completion this year. The university's large Medical Center, in Denver, has made numerous research contributions.

The University of Denver (5941 students), the only large private educational institution between the Pacific Coast and the Mississippi River, has a handsome campus in the southern part of the city and another campus (business administration and law) at the Civic Center. Since 1947 the university has operated the Denver Research Institute. In its chemical, electronics, mechanics, metallurgy, and physics divisions, there are more than 200 scientists and engineers who are working on projects for industrial firms and government agencies.

Colorado State College (4568), at Greeley, and Colorado State University (6131), at Fort Collins, are about 50 and 60 miles to the north, respectively. Colorado College (1331) and the Air Force Academy (1524) are at Colorado Springs, 65 miles to the south. The internationally famous Colorado School of Mines (1047) at Golden, 15 miles west of Denver, is the oldest institution in the United States devoted exclusively to the training of mineral engineers.

The University Corporation for Atmospheric Research, consisting of 14 institutions with degree-granting programs in meteorology, will manage the new National Center for Atmospheric Research on Table Mountain near Boulder. Walter Orr Roberts will serve as director. The Martin Company and other firms connected with the aviation industry have divisions in Denver staffed by research scientists and engineers.

From all this it is apparent that in the Denver area alone there are large potential audiences. But the meeting will attract participants not only from this area but, like all AAAS meetings, from all parts of the world.

Colorado attracts vacationers in winter as well as in summer. The main roads, even the high mountain passes, are kept open; thus, participants will be able to drive to the meeting from all directions, and will be able to visit Colorado Springs and other scenic areas. There are splendid opportunities for skiing, as Denver is at the edge of one of the great skiing areas of the nation. Winter Park, Arapahoe Basin, Glenwood Springs, Loveland Basin, Ski Idlewild, Berthoud Pass, Ski Broadmoor, and Aspen are all close enough to be readily reached by car or bus.

It is not likely that Denver itself will have snow during the week of the meeting. According to the U.S. Weather Bureau, over a 20-year period the average precipitation in Denver during Christmas week has been 0.01 inch per day, or a total of 0.06 inch for the period of the meeting. Denver's weather in December and January is usually invigorating and inviting. With low humidity and sunny skies ("350 days a year," the Convention Bureau says), temperatures at Christmas may range from 20°F at night to 60° or even 70°F in the afternoon—weather typical of the high plateaus of the Southwest. But if it should snow, this would be no problem. Flakes melt immediately in the dry, sun-warmed air or are soon cleared away by the city's snow-removal equipment. No one gets snowbound in Denver in December!

This year's meeting of the Association, the 128th, is unique in that it will be the first national winter meeting of the AAAS to be held in the shadow of the Rockies. This will also be the 38th annual meeting of the Association's Southwestern and Rocky Mountain Division, which has advanced the date of its next meeting from the spring of 1962 to December 1961 to coincide with the dates of the national meeting. The resultant joint meeting will also include a special meeting of the AAAS-affiliated Colorado-Wyoming Academy of Science. A number of regional branches of national societies, such as the Colorado Section of the American Chemical Society, are expected to participate actively. Such strong local support and the programs of the Association as a whole and of its 18 sections, its several committees, and its many participating societies (of astronomers, geographers, zoologists, ecologists, psychiatrists, science teachers, and so forth), make it evident that every principal field of science will be included. This third Denver meeting promises to be not only the greatest meeting of its kind ever held in the Rocky Mountain region but also one of the best meetings in the history of the Association.

Denver is not quite as old as the AAAS; it has just entered upon its second century. In 1850 Cherokee Indians bound for California found gold in Ralston Creek. In 1858, W. Green Russell found gold in Dry Creek. Several settlements of this period were consolidated into one community in April 1860 and were named after Virginia-born James W. Denver, territorial governor of Kansas. Denver's first stores had opened two years earlier (lumber then cost $100 per 1000 board feet; flour, $20 to $40 per 100 pounds; and sugar, coffee, and tobacco, almost their weight in gold dust). The first issue of the *Rocky Mountain News* was issued 23 April 1859. By 1870 there were 1500 buildings and 4759 people. Today, the metropolitan area's population is 929,383, and the city is rebuilding its

downtown area at a pace that changes the skyline every few months.

With the westward shift of the nation's population and with increases in AAAS membership, the number of Association meetings held in the West increased, though at first only gradually. The fifth meeting of the Association, held in 1851 in Cincinnati, was the first to be held west of the Appalachians. In 1872, with the 21st meeting, in Dubuque, Iowa, the AAAS reached the Mississippi in its westward progress. In 1901 the Association's 50th meeting was held in Denver. Finally, 14 years later, the AAAS reached the shores of the Pacific.

Earlier Denver Meetings

The first Denver meeting, in August of 1901, was the regular annual meeting for that year. Sessions were held in Denver High School No. 1; 311 registrants came from 34 states, the District of Columbia, and Canada and there were two visitors from the British Isles.

Arrangements for the meeting were made by the "permanent secretary," the eminent entomologist L. O. Howard, then in the fourth year of 22 years of service in that capacity. The Brown Palace was the headquarters hotel. Rooms were $1.50 and up.

R. S. Woodward, the retiring president, delivered an address on the progress of science, and many members of the community were present. Woodward traced the growth of science in the 19th century and stressed the increasing need for means of communicating the findings of the specialists to the public which supports research.

Charles R. Van Hise of the University of Wisconsin gave a popular lecture on the geology of ore deposits. On another evening, Gifford Pinchot spoke on the government and the forest reserves. Among the vice presidential addresses, Charles B. Davenport of the University of Chicago, speaking on zoology of the 20th century, accurately forecast general developments and concluded with a statement that could still be made today: "Our best students slip from our grasp to go into other professions or into commerce because we can offer them no outlook but teaching, administration, and a salary regulated by the law of supply and demand."

There were 200 short papers, including one on the "disappearance of the vast flocks of wild pigeons in eastern North America," by Edward Tudor Keim of Denver.

A section on physiology and experimental medicine (then Section K, now Section N) was organized at this meeting.

The year before, *Science*, then owned and edited by J. McKeen Cattell, had been made the official journal of the Association, and the cost of subscription was covered by dues. One effect was that the membership of the Association, which had been relatively static for some years, immediately began to increase at a good rate (membership in 1900 was 1925; at the time of the first Denver meeting it was 2703).

A particularly important constitutional amendment passed at this meeting formally set forth the relations of the affiliated societies with the Association and gave the societies representation in the AAAS Council—one or two representatives depending on how many of their members were Fellows of the Association.

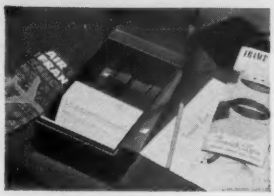
The first Denver meeting was the last of the annual meetings to be held in August. In accordance with the wishes of some of the affiliated societies (the American Society of Naturalists, for example, which had changed its meeting to Christmas week as early as 1883) and of faculty members who found August a difficult date because of the recently established summer schools, the AAAS voted to hold its meeting for 1902 during Christmas week. The week of the meeting was to be the week containing New Year's Day, with sessions before and after 1

Downtown Denver (top) and Red Rock Amphitheatre (bottom).

Kodak reports on:

where a disciple can look for details . . . a reagent for alkyl halides . . . the competitive assault on salt

Small print



This little file holds some 10,000 unabridged pages of technical reports of the French Atomic Energy Commission. The lady who lives in the house across the road may find this astonishing. Your boss may be astonished. Even you may be astonished. But to the reasonably alert librarian the micro-opaque card idea is old hat. Anything we can tell you about it your librarian can tell you better.* We merely draw attention to the following accretions to the available micro-opaque literature:

• *All* the unclassified scientific reports released by the U. S. Atomic Energy Commission.
Even reduced 20× as they are in micro-opaque form, the complete set published to date would fill 250 boxes like the one above. The indexing mechanism for this incredible mass of information is *Nuclear Science Abstracts*, a periodical sold by the Superintendent of Documents, Washington 25, D. C.

• Reports of the Commissariat à l'Energie Atomique.
Naked-eye abstracts in French and English on the front of each card, the complete paper in microform on the back. Sold at 50¢ per card by Microcard Editions, Inc. (901 26th St. N. W., Washington 7, D. C.), who will explain indexing system.

• The 1st Decennial Index to *Chemical Abstracts*, the brilliant chemical years 1907 to 1916.
Contains the roots of many a chemical concept since proliferated beyond the scope of a single mind. On some 60 3" x 5" cards sold by the American Chemical Society (1155 16th St. N. W., Washington 6, D. C.).

• *All* the meteorological data gathered for the International Geophysical Year.
Purpose of whole shebang was to gather lots of data, remember? Here they are, ready to make use of. Ask the World Meteorological Organization (IGY Meteorological Data Centre, 1, Avenue de la Paix, Geneva, Switzerland).

• A project under the auspices of the Committee on Oceanography of the National Academy of Sciences–National Research Council to effect transmittal from all who have to all who want any data or maps on any parameter, physical, chemical, or biological, of the marine environment.
Details from The American Geographical Society (Broadway at 156th St., New York 32).

• *Justus Liebigs Annalen der Chemie* from 1832 to 1958 and *Berichte der Deutschen Chemischen Gesellschaft* from 1868 to 1958.
The New Testament comprises four Gospels; the science of chemistry seems to be founded on only three gospels, less influential spiritually but vastly more voluminous. Microprint overcomes the voluminousness but accomplishes nothing spiritually. The third gospel, *Beilstein*, got the treatment earlier. Microcard Editions, Inc.

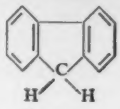
• *The First Six Million Prime Numbers*, 1 (controversial) to 104,395,289.
Result of a 4-day holiday weekend with a large computer and nothing better to do than a favor for mathematicians working in number theory. Microcard Editions, Inc.

For any sustained use of micro-opaques, you need a micro-opaque reader. Ten years ago they were rare. Today the central research library that lacks one is rare. Any scientific discipline that needs to communicate large masses of data to a limited number of its disciples should consider microprint. For suggestions on how to proceed, write Recordak Corporation, 415 Madison Avenue, New York 17, New York (Subsidiary of Eastman Kodak Company).

One week last summer

For many years we have been hiring chemistry graduate students for summer jobs. It gives them a chance to look us over and vice versa. Some of the biggest wheels in the corporation came that way. Others found three months of estival service to mammon sufficient for a lifetime and have become famous professors of chemistry. Still others have slipped through our fingers to become wheels in other companies. (You can't win them all.)

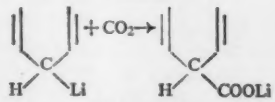
Methyl Fluorene - 9 - Carboxylate (Eastman 8164) represents a week's work last summer by one of these young men. The man he was hired to assist specializes in organometallic reactions. The mentor found a lithium reaction to give him in the April 1960 *Analytical Chemistry* on page 554. The summer man reacted lithium wire with bromobenzene to produce phenyllithium. He used this to replace one of the central hydrogens in



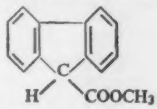
fluorene

by lithium.

Next,



On acidification, an H replaced the Li. He then esterified with methanol, with HCl as catalyst. His product,



was good enough to overcome the skepticism of our genial but skeptical chief control chemist.

Nobody patted him on the head for his accomplishment. All he accomplished was to make it unnecessary for other chemists who look up the *Anal. Chem.* reference to spend a week of their own time preparing the reagent that has been found to react with a wide variety of alkyl halides to yield sharp-melting derivatives. Since such reagents are few and far between, you may even wish to send for a procedural abstract. Or for an employment application form.

Or for Catalog No. 42, listing some 3900 Eastman Organic Chemicals we stock at Distillation Products Industries, Rochester 3, N. Y. (Division of Eastman Kodak Company).

Cellmakers

Charles W. Warren

Paul A. Wilks, Jr.

Meet the founders of Connecticut Instrument Corporation, Wilton, Conn., POrter 2-5545. You can call them up and order any of a number of infrared accessories, including one they call a "C.I.C. Irtran-2 Fixed Thickness Absorption Cell" for $160. This fits directly into the standard cell slides of two of the more popular infrared spectrophotometers. Transmittance: better than 60% from 2 to 12μ. Clear aperture: 25 x 5mm. Nominal pathlengths available: 0.015mm to 1.0mm. Construction of mount: aluminum, with polytetrafluoroethylene spacer.

We are supposed to be angry with these boys. "Irtran-2" is our trademark, not theirs. They buy our Irtran-2 optical flats and build cells with them. Anybody who has the skill and the price can buy Irtran optical parts from Eastman Kodak Company, Special Products Division, Rochester 4, N. Y., and build with them.

Irtran-2 optical material is almost completely insoluble in water, which is more than can be said of the rock salt hitherto used for such cells. It can even be boiled in water and detergent to clean out contamination. It can be used in contact with reasonable concentrations of bases and most acids, including the hydrofluoric. Transmittance extends out several microns beyond that of the slightly water-soluble CaF_2. It resists thermal shock much better than BaF_2. It is about as strong as glass. It has a hardness of 354 Knoop.

A cell made out of it does not change pathlength, as does one of NaCl.

Messrs. Warren and Wilks and associates are making and selling cells of Irtran material as fast as we can shoot the Irtran plates to them. We are so angry that we are giving them this advertising for free.

Kodak
TRADE MARK

*The reason we try to tell you is that we want to sell the raw photographic materials on which microprint cards are printed. We also want to sell microfilm. The librarian can tell you about *that*, too. A new conventional-sized reference, "Guide to Microforms in Print" ($4, Microcard Editions, Inc.), summarizes everything available.

Table 1. Growth of the AAAS since 1937.

Item	1937	1961
AAAS members	18,776	About 64,000
Affiliated academies	30	47
Affiliated societies	132	247

January. A committee consisting of Minot, Woodward, physicist E. L. Nichols, and Cattell was appointed to ask universities and colleges either to postpone their date of reopening after vacation or to excuse their scientific staffs from academic duties while the meeting was in session. An impressive number of institutions immediately altered their calendars in response to this request.

Testimony to the success of the meeting is given in an editorial in the Denver *Post* for 30 August 1901.

> It is believed that the visit of the scientists has been one of pleasure, as well as profit, and that if the people of Denver have taken a thorough satisfaction in their presence, they, on the other hand, have found equal satisfaction in their sojourn here. The public is too apt to think that because men devote their lives to the pursuit of scientific inquiries they are apt to be dry, self-absorbed, and technical. To such as these actual contact with the members showed them to be surprisingly genial, kindly and sympathetic, while in many of them was found a fine flow of humor flavored with a wit which was nonetheless attractive because it carried with it no sting.
>
> In the nature of things it will be some years before Denver may again hope to entertain them as a body, but everyone concerned will feel for them a regard amounting to affection and when their next session is held here they will get a reception such as no other city could accord them.

The second Denver meeting, held in June 1937, was the 100th meeting of the Association and one of two AAAS meetings held that year; the other was the regular December meeting. (The annual meeting had been held in December ever since the Washington meeting of 1902, without interruption even for World War I.) After it had been decided to hold a large meeting annually in December, the Association experimented with the plan of holding a second, summer meeting in smaller cities or on a university campus. Summer meetings were held in June of 1902, 1906, 1908, 1922, and 1925 and in June of every year from 1931 through 1941. Some of these were joint meetings with one or the other of the Western divisions. The second Denver meeting was held jointly with both the Southwestern and Rocky Mountain and the Pacific Divisions of the Association, for the first and only time. These additional, essentially regional or special meetings afforded members in different parts of the nation an opportunity to attend a general scientific meeting, especially during the depression years. It was primarily to meet the need for more scientific meetings in the Far West that the Pacific and the Southwestern and Rocky Mountain Divisions were organized, in 1915 and 1920, respectively.

At the second Denver meeting the presidential address of the Pacific Division, on the development of our knowledge of anterior pituitary function, was given by Herbert M. Evans of the University of California. The annual John Wesley Powell lecture of the Southwestern and Rocky Mountain Division was delivered by A. E. Douglass, director of the Stewart Observatory of the University of Arizona; he spoke on tree-rings and chronology.

There was a special symposium, jointly sponsored by the AAAS and the Ecological Society of America, on scientific aspects of the control of drifting sands. Another program at this meeting, on disease caused by acid-fast bacteria, was sponsored by Section N–Medical Sciences; the papers were published the following year as AAAS symposium volume No. 5, under the title *Tuberculosis and Leprosy*.

Other symposia were concerned with the astrophysical problems of the ionosphere, Rocky Mountain geomorphology, oceanography, Rocky Mountain spotted fever, plant hormones, drought resistance in plants, and genetics and the species problem. There were motion pictures on human physiology and on exploring the universe, presented by A. J. Carlson and Walter Bartky, respectively.

The first Theobald Smith award in the medical sciences, established the previous year by Eli Lilly and Company and administered by the AAAS, was made to Robley D. Evans, of Massachusetts Institute of Technology, for his work on radium poisoning. The award will be given for the 17th time at this year's meeting.

There were numerous participating societies, and 575 papers were read. The official registration was 763 (with registrants from nearly every state, the District of Columbia, and Canada), but it was estimated that at least 1200 attended. All evening sessions were held at the Cosmopolitan Hotel. Others were held in the classroom buildings of the University of Denver and the University of Colorado Medical School, in the Senate chamber of the State Capitol, and in local office buildings.

Among the items of business transacted at the 1937 meeting were the following: (i) approval of a proposal to organize five conferences on science and society, to be held at successive AAAS meetings; (ii) approval of the new constitution of the Pacific Division; (iii) passage of a resolution on maintenance of high standards in the system of national parks; and (iv) consideration of the proposal of J. McK. Cattell that *Science* and the *Scientific Monthly* be transferred to the AAAS upon his death.

In only 24 years, great advances have been made in science. The Association has grown accordingly, as may be seen from the data of Table 1. Inevitably, the third Denver meeting will be larger than the two earlier meetings. Preliminary announcement of the program will be made in the 26 May issue of *Science*.

RAYMOND L. TAYLOR
Associate Administrative Secretary

Forthcoming Events

May

26–3. American Acad. of Dental Medicine, cruise to Bermuda and Nassau. (H. Ward, 15 Bond St., Great Neck, N.Y.)

28–1. Special Libraries Assoc., 52nd annual, San Francisco, Calif. (B. M. Woods, SLA, 31 E. 10 St., New York 3)

29–31. American Gynecological Soc., Colorado Springs, Colo. (A. H. Aldridge, 899 Park Ave., New York 21)

29–31. Cancer Symp., 6th annual, Regina, Saskatchewan, Canada. (A. J. S. Bryant, Allan Blair Memorial Clinic, Regina)

29–31. Chemical Inst. of Canada, 44th annual, Ottawa. (Chemical Inst. of Canada, 48 Rideau St., Ottawa 2)

29–3. Molecular Spectroscopy, 5th European cong., Amsterdam, Netherlands. (D. H. Zijp, Secy., Nieuwe Achtergracht 123, Amsterdam-C.)

30. Nutrition Soc. of Canada, 4th annual, Guelph, Ontario. (E. V. Evans, Dept. of Nutrition, Ontario Agricultural College, Guelph)

31–2. Canadian Federation of Biological Societies, Guelph, Ontario, Canada. (E. H. Bensley, Montreal General Hospital, 1650 Cedar Ave., Montreal 25, P.Q.)

31–2. Radar symp., 7th annual, Ann Arbor, Mich. (Coordinator, 7th Annual Radar Symposium, Institute of Science and Technology, Box 618, Ann Arbor)

June

2–3. Canadian Soc. for Clinical Chemistry, annual general meeting, Guelph, Ont. (C. R. Cameron, Ontario Veterinary College, Guelph)

2–5. Latin-American Congress of Physical Medicine, Lisbon, Portugal. (C. Lopez de Victoria, 245 E. 17 St., New York, N.Y.)

3–11. Medical-Surgical Film Festival, 4th intern., Turin, Italy. (Minerva Medica, Corso Bramante 83–85, Turin)

4–9. Mass Spectrometry, ASTM Committee E-14, Chicago, Ill. (G. Crable, Gulf Research Center, P.O. Box 2038, Pittsburgh 30, Pa.)

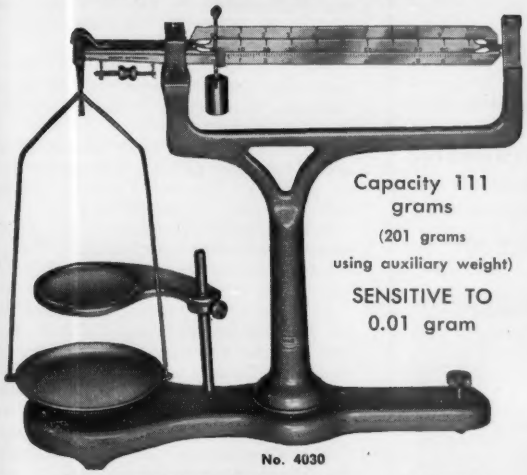
4–10. World Congress of Psychiatry, 3rd, Montreal, Canada. (A. Roberts, Al-

● Good Sensitivity ● High Stability ● Long Service

TRIPLE-BEAM BALANCE

SPEEDY, ACCURATE WEIGHING

All Exposed Parts of *Stainless Steel*



Capacity 111 grams

(201 grams using auxiliary weight)

SENSITIVE TO 0.01 gram

No. 4030

4030.	TRIPLE-BEAM BALANCE, High Form.	Each $27.50
4031.	AUXILIARY WEIGHT.	Each $1.50
4030C.	PLASTIC COVER For No. 4030.	Each $1.60

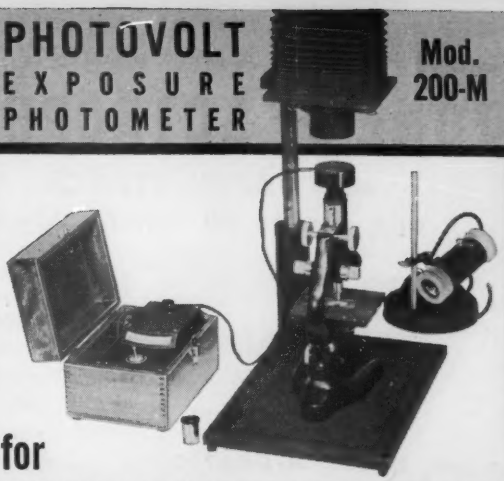
THE WELCH SCIENTIFIC COMPANY

ESTABLISHED 1880

1515 Sedgwick Street, Dept. E, Chicago 10, Illinois, U.S.A.

Manufacturers of Scientific Instruments and Laboratory Apparatus

PHOTOVOLT EXPOSURE PHOTOMETER Mod. 200-M



for PHOTOMICROGRAPHY

Accurate determination of exposure time in black-and-white and color photomicrography

Write for Bulletin #810 to **Price $125.00**

PHOTOVOLT CORP.

1115 Broadway New York 10, N. Y.

Needed Now

Health Physicist:

To direct and perform health physics and industrial hygiene work at various WTR facilities. Work will also include non-health physics engineering that pertains to reactor and hot lab work. Must have A.B. or B.S. degree and additional training in health physics.

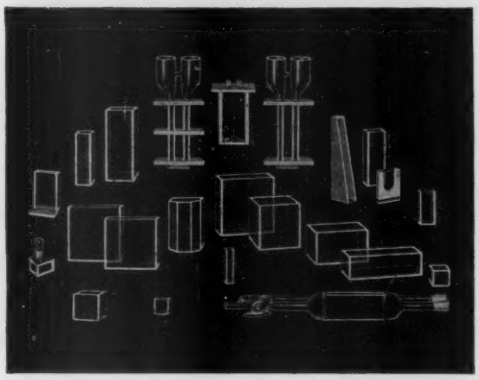
If you qualify for any one of the above positions, write immediately to: Mr. C. S. Southard, Westinghouse Atomic Power Division, P.O. Box 355, Dept. X-76, Pittsburgh 30, Pa.

Westinghouse

ATOMIC POWER DIVISION

FIRST IN ATOMIC POWER

GLASS ABSORPTION CELLS made by ***KLETT***



SCIENTIFIC APPARATUS

Klett-Summerson Photoelectric Colorimeters—Colorimeters — Nephelometers — Fluorimeters—Bio-Colorimeters — Comparators — Glass Standards—Klett Reagents.

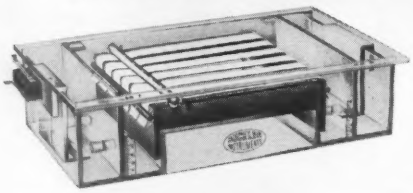
Klett Manufacturing Co.

179 East 87 Street, New York, New York

COMPLETE APPARATUS for

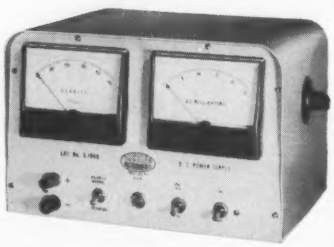
ZONE ELECTROPHORESIS

with PAPER, STARCH, AGAR and almost all other known media!



The most complete and flexible electrophoresis apparatus available, with accessories for all electrophoretic methods using solid media.

- *ONE BASIC MIGRATION CHAMBER can be adapted to all media*
- *D.C. POWER SUPPLIES*
- *AGAR CUTTERS FOR IMMUNO SLIDES*



For complete information and price, please send for Bulletin S3-1000

LABORATORY APPARATUS
BUCHLER INSTRUMENTS
PRECISION INSTRUMENTS

BUCHLER INSTRUMENTS, INC.
514 West 147th Street, New York 31, N. Y.
ADirondack 4-2626

HERE'S A QUALITY STUDENT MICROSCOPE AT A BUDGET PRICE!

Although budget priced, the UNITRON Model MUS is definitely not just another student microscope. It includes these significant features often lacking in much more costly student models:

- NOT JUST a disc diaphragm . . . but an iris diaphragm for perfect control of aperture and contrast.
- NOT JUST a single focusing control . . . but both coarse and fine.
- NOT JUST a mirror . . . but a 0.65N.A. condenser for optimum illumination and resolution.
- NOT JUST two objectives . . . but three: achromatic 5X, 10X, 40X.
- NOT JUST an ordinary eyepiece . . . but a coated 10X Wide Field for large, flat fields.
- PLUS THESE SPECIAL FEATURES . . . larger stage projects beyond objective preventing damage to objectives and nosepiece. Automatic stop for fast focusing and to prevent breakage of specimen slides and optics. Durable, sturdy — withstands the use and abuse of classroom and laboratory.

Price Only $75
($67.50 each in lots 5-10)

ASK FOR A FREE 10 DAY TRIAL
Even higher discounts on quantities more than 10.

UNITRON
INSTRUMENT COMPANY • MICROSCOPE SALES DIV.
66 NEEDHAM ST., NEWTON HIGHLANDS 61, MASS.

Please rush UNITRON's Microscope Catalog. 4-P-1
Name_____
Company_____
Address_____
City_____ State_____

AAAS Symposium Volume 63

CONGENITAL HEART DISEASE

Allen D. Bass and Gordon K. Moe, Editors June 1960

Presented at the AAAS Washington meeting, December 1958.

372 pp., 147 illus., references, index $7.50

AAAS members' cash orders . . $6.50

The recent spectacular advances in cardiac surgery have resulted from the intimate and fruitful collaboration of the surgeons with embryologists, pathologists, internists, pediatricians, physiologists, and engineers. The present volume summarizes the current status of knowledge of congenital heart disease, ranging from the experimental production of developmental anomalies, through the morphology and pathologic physiology, to the diagnosis and surgical repair of congenital lesions, and includes an introductory chapter by the dean of cardiac embryologists, Professor Bradley M. Patten.

British Agents: Bailey Bros. & Swinfen, Ltd. Hyde House, W. Central St. London W.C.1, England

American Association for the Advancement of Science

1515 Massachusetts Ave., NW, Washington 5, D.C.

lan Memorial Inst., 1025 Pine Ave. West, Montreal 2, P.Q.)

4–12. Cellular Regulatory Mechanisms, 26th Cold Spring Harbor Symp. on Quantitative Biology, Cold Spring Harbor, N.Y. (A. Chovnick, Long Island Biological Assoc., Cold Spring Harbor)

5–7. American Soc. for Quality Control, Philadelphia, Pa. (W. P. Youngclaus, Jr., 161 W. Wisconsin Ave., Milwaukee 3, Wis.)

5–7. Fundamental Aspects of Radiosensitivity, symp., Upton, N.Y. (A. H. Sparrow, Brookhaven National Laboratory, Upton, L.I.)

5–8. International Instrument-Automation Conf. and Exhibit, Instrument Soc. of America, Toronto, Canada. (I.S.A., 313 Sixth Ave., Pittsburgh 22, Pa.)

5–9. Animal Reproduction, 4th intern. cong., Amsterdam, Netherlands. (Secretariat, Burgemeester de Monchyplein 14, The Hague, Netherlands)

5–9. Effects of Ionizing Radiation on the Nervous System, symp., Vienna, Austria. (J. Burt, International Atomic Energy Agency, United Nations, New York, N.Y.)

5–10. International Colloquium on Spectroscopy, 9th, Lyon, France. (Secretariat, Groupement pour l'Avancement des Méthodes Spectrographiques, 1, rué Gaston Boissier, Paris 15)

5–16. Operations Research and Systems Engineering, Baltimore, Md. (Dean, School of Engineering, Johns Hopkins Univ., Baltimore 18)

6–8. Tissue Culture Assoc., 12th annual, Detroit, Mich. (F. E. Payne, Dept. of Epidemiology, Univ. of Michigan, Ann Arbor)

8–11. American Electroencephalographic Soc., Atlantic City, N.J. (G. A. Ulett, Malcolm Bliss Mental Health Center, 1420 Grattan, St. Louis 4, Mo.)

8–18. International Organization for Standardization, general assembly (members only), Finland. (American Standards Association, 70 East 45 St., New York 17)

9–11. Society of Biological Psychiatry, Atlantic City, N.J. (G. N. Thompson, 2010 Wilshire Blvd., Los Angeles 57, Calif.)

9–17. European Convention of Chemical Engineering, Frankfurt, Germany. (DECHEMA, Postfach No. 7746, Frankfurt/Main 7)

11–15. American Soc. of Mechanical Engineers, summer annual, Los Angeles, Calif. (O. B. Schier II, 29 W. 39 St., New York 18)

12–13. Radio Frequency Interference, 3rd natl. symp., Washington, D.C. (E. F. Mischler, National Engineering Service, Washington, D.C.)

12–14. American Dairy Science Assoc., Madison, Wis. (H. F. Judkins, 32 Ridgeway Circle, White Plains, N.Y.)

12–14. American Neurological Assoc., Atlantic City, N.J. (M. D. Yahr, Neurological Inst., 710 W. 168 St., New York 32)

12–14. Society for the Study of Development and Growth, regeneration symp., Williamstown, Mass. (A. C. Braun, Rockefeller Inst., New York 21)

12–15. Nature of the Real, conf., Milwaukee, Wis. (E. D. Simmons, Dept. of

Philosophy, Marquette Univ., Milwaukee 3)

12–15. Physics of Electronic and Atomic Collisions, intern. conf., Boulder, Colo. (B. Bederson, Physics Dept., New York Univ., New York 53)

12–16. Association of Official Seed Analysts, Richmond, Va. (D. D. Forsyth, Agronomy Building, Madison 6, Wis.)

12–16. Molecular Structure and Spectroscopy, symp., Columbus, Ohio. (R. A. Oetjen, Dept. of Physics and Astronomy, Ohio State Univ., Columbus 10)

12–18. European Assoc. for Animal Production, 8th intern. cong., Hamburg, Germany. (European Assoc. for Animal Production, Via Barnaba Oriana 28, Rome, Italy)

12–24. European Inst. of Scientific Studies for the Prevention and Treatment of Alcoholism, Amsterdam, Netherlands. (D. Ehlbeck, Intern. Bureau against Alcoholism, Case Gare 49, Lausanne, Switzerland)

12–29. Statistical Quality Control Intensive Courses for the Chemical and Processing Industries, 18th annual, Rochester, N.Y. (H. M. Kentner, Extended Services Div., Rochester Inst. of Technology, Rochester 8)

13–14. Product Engineering and Production, 5th natl. conf., Philadelphia, Pa. (P. J. Riley, R.C.A., Building 10-6, Camden 2, N.J.)

13–16. Gas Chromatography Symp., 3rd biennial, East Lansing, Mich. (J. E. Callen, Procter and Gamble Co., Miami Valley Laboratories, P.O. Box 175, Cincinnati 39, Ohio)

13–16. Institute of Aerospace Sciences and American Rocket Soc., Los Angeles, Calif. (Inst. of Aerospace Sciences, 2 E. 64 St., New York 21)

13–18. Nuclear Congress, 6th, Rome, Italy. (Ufficio Stampa e Relazioni Pubbliche-CNEN, Via Belisario 15, Rome)

14–16. Applied Mechanics Conf., Chicago, Ill. (American Soc. of Mechanical Engineers, Meetings Dept., 29 W. 39 St., New York 18)

14–16. Semiconducting Compounds, conf., Schenectady, N.Y. (W. W. Tyler, General Electric Research Laboratory, Schenectady)

14–16. Theory of Weak and Strong Interactions, conf., La Jolla, Calif. (T. A. Manar, Scripps Institution of Oceanography, La Jolla)

14–17. American Assoc. of Bioanalysts, Dallas, Tex. (L. D. Hertert, 490 Post St., Room 1049, San Francisco 2, Calif.)

16–17. Meteoritical Soc., Nantucket, Mass. (G. L. Rowland, Long Beach City College, Long Beach 8, Calif.)

17–21. American Nuclear Soc., Boston Mass. (O. J. Du Temple, ANS, 86 E. Randolph St., Chicago 1, Ill.)

18–21. American Astronomical Soc., Nantucket, Mass. (J. A. Hynek, Dearborn Observatory, Northwestern Univ., Evanston, Ill.)

18–23. American Meteorological Soc., 193rd natl., and Pacific Div., AAAS, 42nd annual, Davis, Calif. (AMS, 45 Beacon St., Boston 8, Mass.)

18–23. American Soc. of Medical Technologists, Seattle, Wash. (Miss R. Mathaei, Suite 25, Hermann Professional Bldg., Houston 25, Tex.)

19–21. American Soc. of Pharmacognosy, annual summer meeting, Houston, Tex. (R. S. Westby, Eli Lilly and Co., 740 S. Alabama St., Indianapolis 6, Ind.)

19–23. Conference on Carbon, 5th biennial, University Park, Pa. (Fifth Carbon Conf., Pennsylvania State Univ., Conference Center, University Park)

19–23. Current Aspects of Internal Medicine, postgraduate course, American College of Physicians, Iowa City, Iowa. (E. C. Rosenow, Jr., Executive Director, ACP, 4200 Pine St., Philadelphia 4, Pa.)

19–24. Feed Microscopy, annual meeting and special short course, Denver, Colo. (C. Jones, Colorado Department of Agriculture, 3130 Zuni St., Denver 11)

19–30. Astrophysics Seminar, Cloudcroft, N.M. (J. R. Foote, P.O. Box 1053, Holloman Air Force Base, N.M.)

21–1. International Plastics Exhibition and Convention, London, England. (British Plastics, Dorset House, Stanford St., London, S.E.1)

22–23. American Rheumatism Assoc., New York, N.Y. (F. E. Demartini, 622 W. 168 St., New York 32)

22–23. Computers and Data Processing, 8th annual symp., Estes Park, Colo. (W. H. Eichelberger, Denver Research Inst., Univ. of Denver, Denver, Colo.)

22–24. Endocrine Soc., New York, N.Y. (H. H. Turner, 1200 N. Walker, Oklahoma City 3, Okla.)

22–26. American College of Chest Physicians, New York, N.Y. (M. Kornfeld, 112 E. Chestnut St., Chicago 11, Ill.)

23–25. American College of Angiology, 7th annual, New York, N.Y. (A. Halpern, Secretary, 11 Hampton Court, Great Neck, N.Y.)

25–28. American Soc. of Agricultural Engineers, annual, Ames, Iowa. (J. L. Butt, 420 Main St., St. Joseph, Mich.)

25–29. Morphological Precursors of Cancer, intern. symp. (by invitation only), Perugia, Italy. (L. Severi, Div. of Cancer Research, Univ. of Perugia, P.O. Box 167, Perugia)

25–30. American Medical Assoc., 110th annual, New York, N.Y. (AMA, 535 N. Dearborn St., Chicago 10, Ill.)

25–30. American Soc. for Testing Materials, Atlantic City, N.J. (R. J. Painter, 1916 Race St., Philadelphia, Pa.)

25–30. International Union of Leather Chemists Societies, 8th cong., Washington, D.C. (F. O'Flaherty, Dept. of Leather Research, Univ. of Cincinnati, Cincinnati 21, Ohio)

25–30. National Education Assoc. of the U.S., Atlantic City, N.J. (W. G. Carr, 1201 16 St., NW, Washington 6)

26–27. Conference on Vacuum Metallurgy, 5th annual conf., New York, N.Y. (R. F. Bunshah, Dept. of Metallurgical Engineering, New York Univ., New York 53)

26–28. American Soc. of Heating, Refrigerating and Air-Conditioning Engineers, 68th annual, Denver, Colo. (J. H. Cansdale, ASHRAE, 234 Fifth Ave., New York 1)

26–28. Control of Noise, symp., Teddington, England. (Director, National Physical Laboratory, Teddington, Middlesex)

(See issue of 21 April for comprehensive list)

Why a new Pharmacology textbook?

If you have taught or practiced pharmacology during the past 20 years, you have witnessed the tremendous change in the practice of medicine. You have watched the introduction of an enormous number of new drugs each year; the rapid changes in therapy; and finally more recently, the growing demand that the teaching of medicine be changed to better equip the medical student to make intelligent decisions on his own—particularly in the selection of drugs.

***Ready This Month!* Goth**

MEDICAL PHARMACOLOGY

Principles and Concepts

This new pharmacology textbook provides a new approach to the problem of equipping today's medical student with the sound understanding of the fundamentals, principles and concepts of pharmacology that can guide him in making intelligent therapeutic decisions.

Many other pharmacology textbooks still attempt the impossible task of giving more and more definitive medicine and treatment, amassing encyclopedic listings of practically all drugs. This new book presents for the first time a concise, excellently written account of those principles of pharmacology that the student requires for his future growth. It concentrates on the actual mechanism of the disease and the reaction of the drug on the specific tissue, organ, or system of the body. This is the essence of real pharmacologic knowledge for the modern practitioner of medicine.

Principles of absorption, excretion, distribution, drug metabolism and detoxication processes, toxicity and drug hypersensitivity are discussed in detail, including many current concepts not yet available in most other volumes. Great saving of reading time is effected by eliminating repetitious discussions of compounds which have little practical or theoretical importance.

By ANDRES GOTH, M.D., Professor of Pharmacology and Chairman of the Department, The University of Texas Southwestern Medical School, Dallas, Texas. Ready later this month. Approx. 584 pages, 6¾" x 9¾", 49 illustrations. About $11.00.

Gladly sent to teachers for consideration as a text!

The C. V. MOSBY Company

3207 Washington Blvd.

St. Louis 3, Missouri

new england nuclear

For preparing

DIAZOMETHANE-C-^{14}

N-Nitroso-N-methyl-C^{14}-p-toluenesulfonamide

$200 per 0.5 mc
$50 per 100 uc
$35 per 50 uc

CATALOG ON REQUEST

new england nuclear corp.

575 ALBANY STREET, BOSTON 18, MASS. LIberty 2-5964

NO lost experiments with

MICROSCOPIC SLIDE LABELING

Eliminate guesswork . . . greasemark mistakes. Get positive identification. Simply pull tab and a fresh, clean label "pops" out. Fast, self-sticking labels dispensed one at a time. Available in standard or "tissue-high" thickness. They accept pen, pencil, ball point pen or typewriter marking. 1000 labels per carton.

TIME SELF-STICKING LABELS VINYL COATED

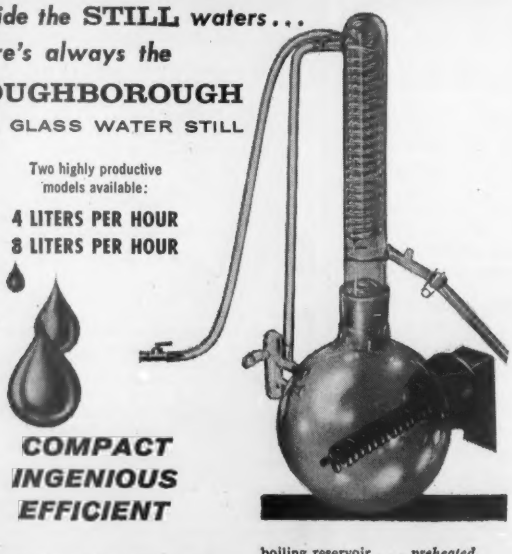
Write for detailed information and the name of your nearest TIME distributor.

PROFESSIONAL TAPE CO., INC.
360 Burlington Ave. • Riverside, Ill.

beside the **STILL** *waters . . .*
there's always the
LOUGHBOROUGH
ALL GLASS WATER STILL

Two highly productive models available:

4 LITERS PER HOUR
8 LITERS PER HOUR



COMPACT
INGENIOUS
EFFICIENT

COMPACT: Only 3 components: condenser, boiling reservoir, immersion heater (automatic overload protected).

INGENIOUS: Reservoir fills tap and automatically maintains constant water level. Cooling water in condenser recycles to boiling reservoir . . . *preheated*. Steam trap allows only vapor to enter condenser—no solids.

EFFICIENT: Distillate produced is pyrogen free and analyses have shown it to contain less than one part in 10 millions of iron, copper, chromium or nickel.

Write for brochure LSI—S

Bellco GLASS INC. VINELAND, N.J.

Calcification in Biological Systems

AAAS Symposium Volume No. 64

Edited by R. F. Sognnaes — July 1960

526 pp., 283 illus., $9.75,
AAAS members' cash orders, $8.50

This monograph deals comprehensively with the mechanism of mineral deposition throughout the animal kingdom. Current research approaches, findings and hypotheses are presented by investigators representing disciplines ranging from physical chemistry and histochemistry to electron microscopy and tissue culture. The central theme revolves about the question, "Why do certain normal and pathological tissues calcify?"

The 22 chapters are organized in an evolutionary sequence; (1) calcification within unicellular organisms and various lower animals, that is, the shells of the mollusc, the gastrolith and exoskeleton of the lobster, the mineralizing leg tendon of the turkey and the otolithic organ of the rat; (2) elements and mechanisms involved in the calcification of cartilage, bone, dentin, enamel and various pathological concretions; (3) experimental observations in organ transplants and in tissue culture; and culminating with (4) the physical and chemical nature of and relationship between the ultimate inorganic and organic building blocks most typical of normal calcification in the human organism.

English Agents: Bailey Bros. & Swinfen, Ltd.
West Central Street
London W.C.1, England

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
1515 Massachusetts Avenue, NW
Washington 5, D.C.

New Products

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Neither Science *nor the writer assumes responsibility for the accuracy of the information. All inquiries concerning items listed should be addressed to the manufacturer. Include the department number in your inquiry.*

■ VIBRATION METER provides standardized simultaneous output signals of displacement, velocity, and acceleration by double integration of the output of a piezoelectric accelerometer. A dial adjustment is provided that permits adjustment for accelerometer sensitivity to provide output of 1 volt/in. and 1 volt/grav. The velocity signal is standardized to 96.4 mv (r.m.s.)/in. per sec. A 25-ft., driven-shield cable is furnished to reduce cable capacitance effects. (Unholtz-Dickie Corp., Dept. Sci178, 2994 Whitney Ave., Hamden, Conn.)

■ VOLTAGE-TO-FREQUENCY CONVERTER is a completely solid-state device available in eight models, which provide full-scale output frequencies of 30 to 25,000 cy/sec. The maximum full-scale frequency is adjustable over a 4-to-1 range. Input ranges available are 0 to 1, 0 to 10, and 0 to 100 volts. Input-output linearity is said to be ±0.25 percent. Linearity of ±0.1 percent is available. (Pioneer Magnetics, Inc., Dept. Sci176, 850 Pico Blvd., Santa Monica, Calif.)

■ SIGNAL COMMUTATOR is a solid-state multiple-input commutator that produces full-scale output voltages of 5 or 10 from millivolt-level sources such as thermocouples, strain gages, and the like. The basic module provides 16 channels; the suggested maximum scanning rate for one module is 2 kcy/sec; time interlacing two or more modules permits higher output rates. Input is balanced and isolated with nominal ±50 μa for full-scale output; resistance of input winding is 20 ohms. Output is unbalanced, ±5.0 volts into 5000-ohm load with load capacitance of 0.02 μf maximum and maximum sampling period of 10 msec. Linearity is said to be better than ±0.2 percent of full scale. Cross-talk is said to be less than 0.1 percent of full scale with application of full-scale input to any other channel, and less than ±0.3 percent with application of 10 times the input to any other channel. Gain stability is specified as ±0.1 percent per day after a 2-hr warmup, and zero stability ±0.35 percent per week after a 4-hr warmup. Each channel has a balance control that allows output voltage for zero reference or initial input to be set at any reference level between ±5 volts, and each channel is provided with a range potentiometer to set its voltage sensitivity and a jack to insert calibrating voltage. (San Diego Scientific Corp., Dept. Sci182, 3434 Midway Dr., San Diego 10, Calif.)

Fig. 1. Vibration isolation table.

■ VIBRATION ISOLATION TABLE (Fig. 1) is designed to isolate sensitive equipment from horizontal vibration. The table consists of two platforms separated by three steel balls. An instrument placed on the top platform is isolated from a maximum of ½-in. peak-to-peak horizontal motion of the lower platform, and the latter is similarly isolated from horizontal motion of the top platform caused by a supported vibrating device. No resilient support that may change with time is used, so that the table, once leveled, will remain level for an indefinite period of time. (Tenlo Research, Inc., Dept. Sci173, 9424 Lyndale Ave. South, Minneapolis 20, Minn.)

JOSHUA STERN
National Bureau of Standards, Washington, D.C.

The Market Place

BOOKS • SERVICES • SUPPLIES • EQUIPMENT

DISPLAY: Insertions must be at least 1 inch in depth. Weekly invoices will be sent on a charge account basis—provided that satisfactory credit is established.

Single insertion	$48.00 per inch
4 times in 1 year	44.00 per inch
13 times in 1 year	42.00 per inch
26 times in 1 year	40.00 per inch

PROOFS: If copy is to be set, and proofs submitted for approval, complete copy and cuts must be received 4 weeks in advance of publication date (Friday of each week); complete plates no later than 3 weeks in advance of publication date.

PROFESSIONAL SERVICES

ANALYTICAL SERVICES

Amino Acid Analysis of proteins, physiological fluids, peptides, foods, and tissue extracts by the Spackman, Moore, Stein ion-exchange method, using the latest model Beckman-Spinco Analyzer.

Infrared Spectroscopy using the Beckman IR-4 spectrophotometer.

Fluorometric Methods with the American Instrument spectrophotofluorometer.

Gas Chromatography with the Beckman GC-2

Rates and other details available.

RIVERTON LABORATORIES, INC.
852 Clinton Avenue
Newark 8, New Jersey
Essex 4-9550 - Whitehall 4-5584.

PROFESSIONAL SERVICES

WISCONSIN ALUMNI RESEARCH FOUNDATION

LABORATORY SERVICES
for the FOOD, FEED, DRUG and CHEMICAL INDUSTRIES
Analyses, Biological Evaluation, Toxicity Studies, Insecticide Testing and Screening, Flavor Evaluation.
Project Research and Consultation
Write for Price Schedule
P. O. Box 2217 • Madison 1, Wis.

BOOKS AND MAGAZINES

Your sets and files of scientific journals

are needed by our library and institutional customers. Please send us lists and description of periodical files you are willing to sell at high market prices. Write Dept. A3S, CANNER'S, Inc. Boston 20, Massachusetts

SCIENTIFIC JOURNALS WANTED

Sets, Runs and Volumes bought at top prices. Your wants supplied from our Back Files of over 3,000,000 periodicals. Abrahams Magazine Service N. Y. 3, N. Y.

SUPPLIES AND EQUIPMENT

YOU NEED THIS **FREE** CATALOG FOR YOUR FILES

Serums, antiserums and bloods of all kinds for technicians and tissue culture laboratories. No salesman will call.

COLORADO SERUM CO.
4950 York St. • MAin 3-5373 • Denver 16, Colo.

SUPPLIES AND EQUIPMENT

CLIMAX
AUTOCLAVES
RECTANGULAR & CYLINDRICAL
ALL SIZES — ALL HEATS — 45 YEARS MFRS.
WRITE FOR LITERATURE
THE HOSPITAL SUPPLY CO., 304 E. 23 St., N.Y. 10

"From the hand of the veterinarian to research"®

albino rats
CHARLES RIVER *CD
(Caesarean derived)
CHARLES RIVER SD
(Sprague-Dawley descendants)
CHARLES RIVER W
(Wistar descendants)

HYPOPHYSECTOMIZED RATS

- Only Charles River CD animals used
- Rigidly controlled environment (same bldg.) birth to surgery.
- High speed surgery by graduate biologists.
- 10 years experience animal surgery.
- Overnight air service from Boston

* Trademark

THE CHARLES RIVER BREEDING LABS
1018 Beacon St., Brookline 46, Mass. RE. 4-2000
Henry L. Foster, D.V.M., President

PERSONNEL PLACEMENT

CLASSIFIED: Positions Wanted, 25¢ per word, minimum charge $4. Use of Box Number counts as 10 additional words. Payment in advance is required.

COPY for ads must reach SCIENCE 2 weeks before date of issue (Friday of every week).

DISPLAY: Positions Open. Rates listed below—no charge for Box Number. Rates net. No agency commission. No cash discount. Minimum ad: 1 inch. Ads over 1 inch will be billed to the nearest quarter inch. Frequency rate will apply to only repeat of same ad. No copy changes. Payment in advance is required except where satisfactory credit has been established.

Single insertion	$40.00 per inch
4 times in 1 year	38.00 per inch

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

Replies to blind ads should be addressed as follows:

Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

POSITIONS WANTED

Biologist, Ph.D., 5 years' experience, desires teaching-research position, Northeast or Midwest. Box 95, SCIENCE. 5/12

Botanist, Ph.D. June; experimental plant embryology, tissue culture, and biochemistry. Desires research or teaching position. Box 92, SCIENCE. 5/5

Botanist, experienced in university teaching, publications. Box 96, SCIENCE. X

Chemist, Ph.D. inorganic, minor physical; 8 years at large university; 4 years at outstanding research institution; since 1959, industry. Specialties nonaqueous chemistry, electrochemistry. Age 48, family. East Coast. Box 98, SCIENCE. X

Cytochemist-Immunologist Ph.D. (1955). Broad background in zoology, virology, and experimental pathology. Academic appointment in high-caliber medical or graduate school or top-ranking college desired. Location secondary to teaching and research facilities. Assistant professor, $9000 (minimum). Box 100, SCIENCE. X

Medical Biologist, Ph.D., D.V.M. Virology, tumors; clinical experience. Administrative, research, teaching experience. Major academic appointment only. Box 94, SCIENCE. X

Microbiologist, Ph.D.; 8 years of teaching experience. Research with viruses in animals and cell cultures. Desires academic appointment with teaching and research. Available 1 July 1961. Box 99, SCIENCE. 5/12

(a) **Organic Chemistry** Ph.D., physical chemistry minor; experienced in drug synthesis and product development; prefers pharmaceutical development, technical director of medicinal chemistry, or administrative appointment. (b) **Cytology** Ph.D., hematology, radiochemistry minors; experienced in cancer and blood research, teaching and administrative duties; interested in clinical or academic teaching with research opportunity. (Please write for information regarding these and other scientists in all fields; nationwide service.) S5-1 Medical Bureau, Inc., Science Division, Burneice Larson, Chairman, 900 North Michigan Avenue, Chicago. X

Pharmacologist. B.S., male; 11 years of industrial pharmaceutical research. Publications. Desires challenging industrial position. Box 101, SCIENCE. 5/12

Plant Physiologist, Ph.D., dismissed for "unsatisfactory teaching," subsequent to participation in peace walks and favorable reports on trip to Cuba, desires position teaching general botany and/or beginning plant physiology, or doing research such as water relations, translocation, mineral nutrition; 6 years of college teaching experience; age 52. Box 93, SCIENCE. X

Research M.D. Original major papers in clinical, biochemical, physiological research—sole author. Patents (pend.). Associated fields of competence: zoology, physics, chemistry, mathematics. Other major avocational works. Age 31. Married. Recent release from service (USAF research laboratory). Desire position in department of experimental medicine or equivalent. Box 97, SCIENCE. X

POSITIONS OPEN

EDITORIAL ASSISTANT

To help determine acceptability of papers, with aid of journal's scientific advisers. Also to edit manuscripts. Scientific background necessary. Editorial experience helpful. Salary open. Washington, D.C. Box 61, SCIENCE.

Research assistant, female.—Experience in tissue culture and virology. Research and teaching. Prefer M.S. in virology or biology. Send summary of training to **Personnel Director, Baylor University College of Medicine,** 1200 M. D. Anderson Boulevard, Houston 25, Texas.

VIROLOGIST

To plan and conduct investigational, diagnostic, base-line, and surveillance studies of viruses and related organisms in the Hawaii state public health laboratory. Requires 2 years' experience in propagating, detecting, and identifying viruses and completion of graduate work leading to a Ph.D. in virology, bacteriology, or a related field. Salary $8256–$10,536 per annum. Write to Department of Personnel Services, 825 Mililani Street, Honolulu 13, Hawaii.

POSITIONS OPEN

(a) **Professor-Chairman Physics Department** to develop research program with some teaching at state university with new science center. $9000–$11,000 year, 9-month basis; Midwest. (b) **Pharmacology Assistant Professor** for teaching and individual research at medical school; around $8000–$9000; Midwest. (c) **Senior Cancer Research Scientist** qualified in biochemistry for studies on mammary tumors at large research institution; East. (d) **Pharmacologist** for studies on activity of untested new chemicals for expanding pharmaceutical firm; around $10,000; Midwest. (e) **Biochemist** to head division in private laboratory of pathologists serving many hospitals; around $10,000; Southwest. (f) **Animal Physiologist** for research on reproduction with limited graduate teaching at agriculture experiment station of leading university; $7300 up; East. (g) **Control Chemist** for new ethical pharmaceutical unit of established firm; $8000–$10,000; Midwest. (h) **Veterinarian** for clinical evaluation of new products and technical services with pharmaceutical firm. (i) **Agricultural Biochemist** for studies on flavor and enzyme systems of peanut plants at experimental station of university offering academic rank and benefits; $9000; South. (j) **Teaching Appointments** in biology, physics, chemistry, zoology, botany at various liberal arts and state teachers colleges. (Please write for details; also many other positions available through our nationwide service.) S5-1 Medical Bureau, Inc., Science Division, Burneice Larson, Chairman, 900 North Michigan Avenue, Chicago.

COURSES

COURSES

INTRODUCTION TO GENERAL PATHOLOGY

for graduate students and investigators who do not have a medical background

26 June–15 July 1961

HARVARD MEDICAL SCHOOL, Boston, Mass.

The course will be geared to graduate students and Ph.D.'s. It is intended to present the most important areas of General Pathology to investigators in the biological field who do not have a medical background, and wish to become acquainted with the basic mechanisms of disease at the level of cells and tissues.

Experimental methods will be emphasized. The course will consist of lectures, laboratories, and demonstrations. The following areas will be covered:

DISEASE AT THE LEVEL OF CELLS – INFLAMMATION – CIRCULATORY DISTURBANCES – TUMORS – ALLERGY

No Tuition. A limited number of fellowships will be available.
Information: Dr. G. Majno, Department of Pathology, Harvard Medical School, 25 Shattuck Street, Boston 15, Mass.

FELLOWSHIPS

FELLOWSHIPS

RESIDENCY IN EPIDEMIOLOGY

A 3-year residency in epidemiology is now offered by the New York State Department of Health. In this residency a small number of physicians and others with doctorates in related fields will be trained as epidemiologists. Heavy emphasis will be placed on the coordination of clinical, laboratory, and field investigations, and on research methods, particularly as applicable to diseases of noninfectious and unknown etiology.

Fellows in this program during the first year will work with practicing epidemiologists concerned with both applied and research problems. They will also have opportunity to observe other public health activities during this period. During the second year Fellows will be expected to attend one of the 11 graduate schools of public health and to meet the full requirements for the Master of Public Health degree. The terminal 16 months of the fellowship will be spent in substantially independent research. Those with appropriate previous experience may enter the program at the second- or third-year level.

Fellows will receive full support, tuition, and dependency allowances throughout the 3 years.

Requests for application forms and additional information should be addressed to William Haddon, Jr., M.D., Director, Epidemiology Residency Program, New York State Department of Health, 84 Holland Avenue, Albany 8, New York.

INFRARED NEWS

from **Baird-Atomic**

INFRARED DOUBLE-BEAM RECORDING SPECTROPHOTOMETER

Model NK-1 features fastest scan for a given resolution and higher ultimate performance than any other commercial IR prism instrument

A new IR instrument with new versatility which makes it ideal for both routine control and most research investigations.

. . . a new and thoroughly researched *Automatic Scan Control* and *Accelerated Scan Program* . . . covers the 2-16 micron region in 4 minutes rather than the 14 minutes previously required — with no sacrifice in performance!

. . . 100 mm x 80 mm prism, wide globar source and sealed bolometer detector combine to provide highest ultimate resolution and signal-to-noise ratio.

. . . Covers wavelengths from 0.2 μ to 38 μ (with attachments).

. . . Wide line of accessories include 20-meter gas cell, ultra-micro liquid and gas cells, micro-beam condensing system.

Write today for more information on this pace-setting B/A instrument.

Engineers and scientists investigate challenging opportunities with Baird-Atomic

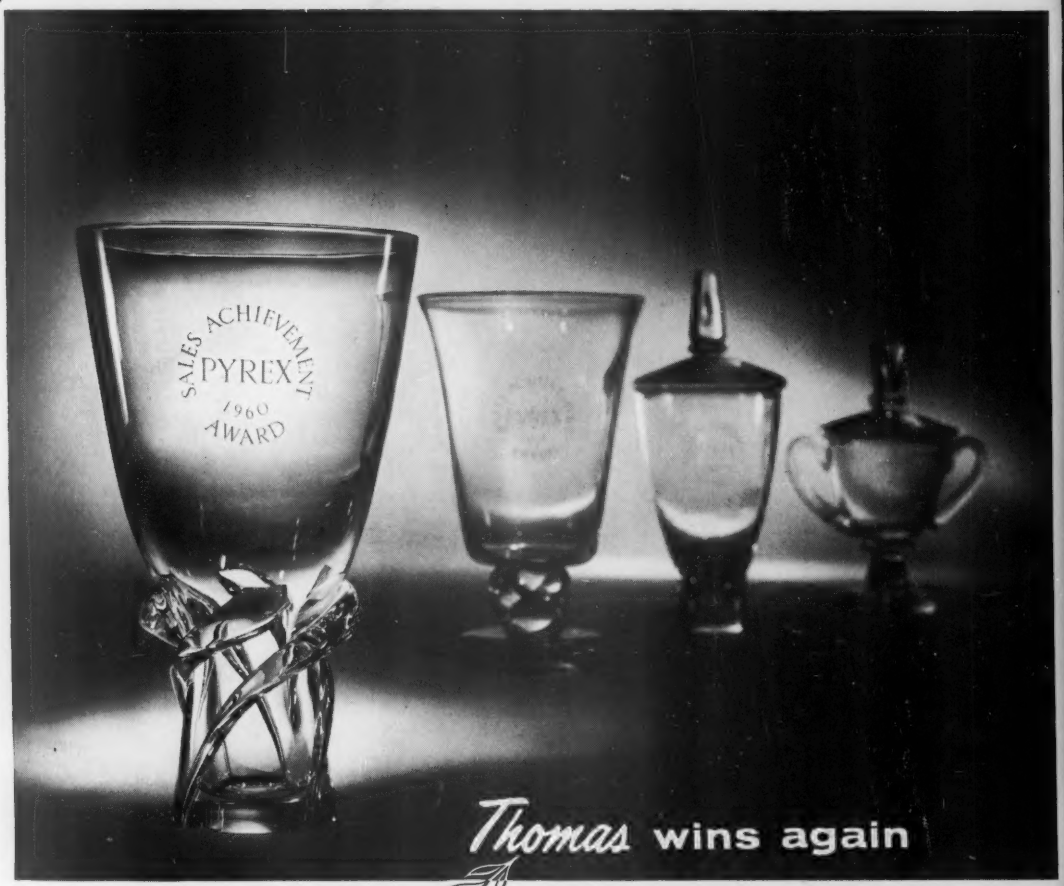
BAIRD-ATOMIC, INC.

33 university road · cambridge 38, mass.

OFFICES IN LEADING CITIES OF U.S.A.

ADVANCED OPTICS AND ELECTRONICS . . . SERVING SCIENCE

4th time winner...



Pyrex Achievement Award for outstanding sales of PYREX LABORATORY GLASSWARE

As in the three former years since establishment of the award by the Corning Glass Works, we are again recipients of the Steuben crystal trophy for outstanding sales of Pyrex laboratory ware.

We regularly list and stock more than 1,500,000 pieces of Pyrex ware—not including Tubing or Rod—and are therefore prepared to make immediate shipment of orders for either large quantities or varied assortments.

See our new 1961 catalog for current listings of the widest assortment of Pyrex laboratory glassware available from any single source.

QUALITY AND SERVICE
A.H.T.CO.
PHILA. U.S.A.
LABORATORY APPARATUS

ARTHUR H. THOMAS COMPANY

More and more laboratories rely on Thomas / *Laboratory Apparatus and Reagents*

VINE ST. AT 3RD • PHILADELPHIA 5, PA.